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BULLETIN
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[656]

Competition by roads, waterways and airways.

(*Continuation*) (1).

Italy, Algeria and French Indo-China.

ITALY.

The Ministry of Communications, General Management of the State Railways, has sent us the following text of the law of the 20th June 1935—XIII, regulating the carriage of goods by road motor vehicles.

As will be seen from the translation of the text given below, the law establishes a system of authorizations or concessions in the case of all goods transport carried out on behalf of a third party. Motor vehicles belonging to private individuals can only be used to transport the goods of their owners when authorised to do so.

Law No. 1349 of the 20th June 1935. — XIII.

Clause 1. — All services for the transport of goods by motor lorry including trailers, carried out on behalf of a third party for reward must be duly licensed by the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles).

The goods services included in the above paragraph are divided into :

a) Hire services, including the hire of motor vehicles without driver;

b) Public local goods services;

c) Public line goods services.

The use by anyone of his own motor lorries, including trailers, to transport his own goods, is subject to a special transport licence issued by the Ministry of Communications through the local Railway Headquarters, on application, the licence book being endorsed accordingly.

Any person operating vehicles with-

(1) See *Bulletin of the Railway Congress Association* starting with the June 1934 issue.

out the transport licence referred to in the previous paragraph, or using his vehicles to transport goods on behalf of a third party, is liable to a fine of 200 to 2 000 lire.

Should the offence be repeated, the Prefect can order the transport licence to be revoked, and the driving licence suspended for a period of from one to six months.

An appeal against this verdict can be made to the Ministry of Communications within 30 days, but this does not delay the application of the penalties imposed.

HEADING I.

Hire services and local services for the transport of goods.

Clause 2. — The authorisation to work hire goods services is granted by the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles) to firms of recognised integrity and technical and financial standing, affiliated to the competent syndicate, on the recommendation of the provincial Corporate Economic Council as regards the number and kind of the authorisations issued for each province.

The Minister of Communications is authorised to decide by special decree to be published in the *Gazzetta Ufficiale* of the Kingdom, the documents which have to be produced by applicants and the procedure to be followed.

Clause 3. — Motor vehicles and trailers on hire for the transport of goods cannot stand in public places to await hire, except when being loaded or unloaded on behalf of the consignor or consignee.

Clause 4. — Local goods services are public services, and the vehicles must be fitted with taximeters inspected by the General Inspectorate of railways, tramways, and motor vehicles; they must not be used outside the limits of the province to which they belong.

The authorisation for these services in granted by the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles) under the conditions laid down in the first paragraph of clause 2. It is valid for nine years and is renewable.

Clause 5. — When the hire and local services are carried out without the prescribed authorisation, the Prefect can suspend the defaulter's driving licence for from one to six months without further formality.

HEADING II.

Public line services for the carriage of goods.

Clause 6. — Public line services are those which work over a given route according to a fixed timetable on behalf of a third party on payment of the prescribed rates, with the obligation to deliver within a certain time limit, with stops at given places for consignment and delivery purposes. They must be worked for anyone wishing to use them.

Clause 7. — Concessions for operating public line services are granted by the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles) to firms of recognised integrity and technical and financial standing, affiliated to the competent syndicate. The concession can be :

a) Provisional;

b) Permanent.

Provisional concessions are granted for a year during which period they can be revoked at any time; if need be a provisional concession can be extended for a second year.

When the concession holder, during

the provisional period, asks for the concession to be made permanent, the provisional concession is extended until the enquiry is completed.

Concessions, which on the previously given advice of the Higher Council of Public Works, are granted for a maximum period of nine years, are permanent ones.

The concession holder, whose services have been operated regularly, has the preference over any other applicants for the renewal of the concession, when all other conditions are equal.

Clause 8. — Permanent concessions are granted by Royal Decree and registered at the Audit Office.

The licence gives all the specifications and conditions both technical and financial upon which the concession is granted.

The Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles) approves the rates which must safeguard the interests of the public.

Clause 9. — A sum of 1 000 to 20 000 lire, according to the importance of the concession, has to be deposited as guarantee in the case of public regular goods services.

Clause 10. — The public line services have to be run regularly during the period of the concession so that the motor vehicles or fixed equipment must not be used for other purposes without the preliminary consent of the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles).

The allocation of the motor vehicles used for public services is specially recorded in the public register of motor vehicles.

In the same way, motor vehicles and equipment allocated to such services cannot be withdrawn from the service without the consent of the Ministry of Communications, even if sequestrated on behalf of a third party.

Clause 11. — The prior claim to new concessions for public line motor services is reserved to the operator or concession holder of the railway, trammay, funicular, or inland water service which the new concession will replace, compete against, or absorb.

When several undertakings claim priority the decision rests with the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles).

In every case the regulations of clause 2 of the Royal Decree No. 1496, of the 14th October 1932, remain in force.

Clause 12. — When no one lays claim to priority as mentioned in clause 11, preference for the new concession, all things being equal, is given to the licensee of motor services in the neighbourhood.

The question of proximity depends not only upon the material concession or the closeness of the routes worked, but also on the whole financial position and the object of the service.

In every case, affiliation with the competent syndicate is obligatory.

Clause 13. — Any modifications to, or substitution of, the firm holding the concession must be approved beforehand by the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles).

When approval is not obtained, the licence can be withdrawn and the caution money refunded.

The concession can likewise be withdrawn and the caution-money refunded when, on the request of the concession holder, it is found to be desirable to cancel the service or when the service has been suspended of necessity due to unforeseen circumstances, and it is not possible or advisable to restart it within a maximum delay of six months.

Clause 14. — Any person, not holding the prescribed licence, who publicly operates with his own motor vehicles or with those of a third party, goods services over given routes which are already covered by a public service holding a concession according to the terms of the present decree, with specified destinations and at more or less regular intervals, is acting illegally.

The offender is punished, according to clause 20, paragraph I, of the Royal Decree No. 2383, of the 30th December, 1923, and the motor licence for the vehicle with which the offence was committed, is withdrawn.

Withdrawal of the licence is ordered by the Prefect after consultation with the Financial Intendant and the Railway Inspectorate. In each case the Prefect reports to the Ministry of Communications (General Inspectorate of railways, tramways, and motor vehicles) the period of availability of the licences withdrawn, with particulars of the motor vehicles in question.

The licence is withdrawn for a period of from one to six months.

If the offence is repeated, the licence is withdrawn for a period of from three months to one year.

Appeal against the decision of the Prefect can be made to the Ministry of Communications within 30 days from the date when the driving licence was suspended. The penalties imposed are not suspended until such time as the appeal is dealt with.

Clause 15. — Any concession holder infringing the conditions of the concession or the orders of the supervising authority can be fined 50 to 500 lire.

Clause 16. — The concession is cancelled and the caution-money confiscated when :

1. the estimated business capacity of the firm holding the concession is being reduced;

2. the working is not begun within the time laid down, or is carried out irregularly;

3. the service is suspended for reasons other than unforeseen ones during 15 days on end, or intermittently for periods which, taken together, exceed 60 days in one year;

4. the concession holder hinders in any way the carrying out of the official regulations issued in accordance with the law;

5. the concession holder gives up the service.

In the case given under (1), withdrawal of the concession must be preceded by a warning to the firm, sent by registered letter, the receipt of which must be acknowledged.

HEADING III.

General regulations.

Clause 17. — Each motor lorry must carry on its radiator a diagonal stripe from right to left, the colour of which, as indicated below, shows for what kind of service it is registered :

1. white for hire services;
2. blue for local services;
3. green for line services;
4. red for transport carried out by the owner on his own behalf.

The mark must also be shown on the back of the motor lorry or trailer.

Any one operating a vehicle not so marked is liable to a fine of from 100 to 1 000 lire.

If the offence is repeated, the Prefect withdraws the driving licence for the vehicle for a period of from one to six months.

Clause 18. — When it is found advisable to set up a station for the use of one or several motor services, whether for goods or passengers, the approval of the Ministry of Communications (General Inspectorate of railways, tram-

ways, and motor vehicles) amounts to a declaration of its public utility.

Clause 19. — The police who have to report offences against the traffic regulations according to the terms of clause 122 of the royal decree No. 1740 of the 8th December, 1933, must also report those against the present law.

The police in question include the officers, sergeants, and men of the special militia forces : railways, ports and post office.

Clause 20. — All the regulations applying to public transport services worked by private industry remain in force so long as they comply with the present law.

Clause 21. — All transport of goods by means of motor lorries, including trailers, must be regularised in accordance with the provisions of the present law within a period of two years from the date it came into force.

Applications in pursuance of the law must be made, within three months from the publication of this law, to the competent Railway Inspectorate. The distinctive signs mentioned in clause 17 must be used within the same period.

Clause 22. — The Government is authorised to include in the unified code to be drawn up according to clause 38 of the Royal Decree No. 2150, of the 2nd August, 1929, the provisions of the present law and of any others that have been or will be made in connection with public transport services worked under licence by private industry.

ALGERIA.

Algerian Railways.

During the first quarter of 1935, the work of the Coordination Committee set up by the decree of the 7th August 1934 was continued, as regards passenger transport, following the principles adopted in France.

During the second quarter of 1935 the application of zone rates to passenger transport continued to give good results, the increase in the receipts for the first quarter being 4.45 % over the same period of 1934.

The application, as from the 1st June 1935, of new passenger fares on the Morocco Railways and the six hours reduction in train time introduced with the new timetables between Algeria and Morocco brought back a considerable number of people to the railway, although the competing services also appreciably reduced their rates.

In goods traffic, the new fixed rates for carrying wine in barrels has made it possible to fight with a certain measure of success against the transport carried out in tank lorries.

As far as the rolling stock is concerned, a scheme for the purchase of three Renault railcars for the Algiers to Bougie and Tizi-Ouzou lines has been submitted for approval to the Governor General of Algeria.

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INDO-CHINA.

Chemins de fer de l'Indochine et du Yunnan.

(2nd quarter 1935).

The Company has introduced various rating measures in the case of goods traffic : prorogation of the fixed rates for full wagon loads from or to Hai-Fong, and the application of two special rates for fuel alcohol and mineral fuel oils.

[624. 63 (.493)]

Bridge works in connection with the electrification of the Brussels-Antwerp line,

by R. DESPRETS,

Engineer, Belgian National Railways Company,
Professor at the University of Brussels.

The introduction of fast and frequent services of electric trains between Brussels and Antwerp involved certain rearrangements of the existing tracks in order that the electrified tracks should not cross other tracks and to abolish all level crossings with either railways or roads.

The most important works were the raising of the electrified lines in Malines station over the Louvain canal on a fixed bridge and the cutting out of the level crossings with the Tervueren road and the Malines-Muysen-Louvain railway; the lowering of the Hove to Berchem line so that the roads and railways could be carried over it on bridges in place of the old level crossings; and the replacement of a number of level crossings at Wavre-Ste-Catherine, Duffel, Contich, Hove, etc. by over- and under-bridges.

The programme, in addition to the extensive earthworks, involved the building of many reinforced concrete, steel, and composite bridges. These works will be described briefly in this note.

Each structure, with its foundations, was designed to the smallest detail so that all that was necessary during the actual constructional work was to work exactly to the drawings.

These structures represent the final result of a long series of careful investigations and designs which had been used at different points on the system (1). In describing them, therefore, we must refer to existing bridges if we are to avoid dealing with developments in a way outside this article. Truth likewise compels us to point out that the steel railway bridges at Malines and Herenthals, the largest standard-gauge Vierendeel girder railway bridges built to date, have been designed and built on new lines.

These structures were all designed in the Structural Drawing Office with the collaboration of the Civil engineers Messrs. Degreef, Clément, De Ryckere, and the chief draughtsmen Messrs. Doison and Lebon.

* * *

Reinforced concrete road bridges.

Such bridges have been built at Wavre-Ste-Catherine, Contich, Duffel, and Hove to carry the road over the railway, or as footbridges.

Reinforced concrete has been used in preference to steel as being cheaper in first cost and maintenance, and as being less liable to corrosion from locomotive smoke. This latter property is only obtained when the reinforcement is thoroughly well embedded in the concrete and is at a sufficient and constant distance from the shuttering.

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(1) See *Bulletin of the International Railway Congress Association*, November 1934, p. 153

Straight girder bridges.

These reinforced concrete bridges are usually of the following types :

a) those carried on concrete abutments, or

b) those carried on simple or crutched intermediate supports.

Bridges carried on concrete abutments are usually more costly than those with intermediate supports. In some cases the arrangement of the lines is such that the latter type can only be used with difficulty. When ordinary solid abutments are used they can be lightened considerably by reinforcing them just sufficiently to tie the whole together, whilst still retaining the character of ordinary (« non reinforced ») concrete.

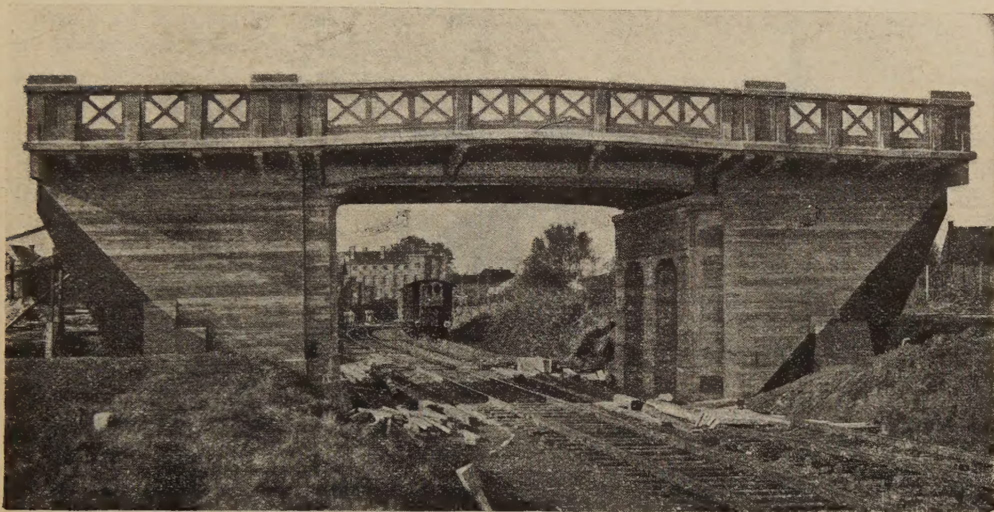


Photo 1. — Straight girder over-bridge at Contich.

The only bridge of this type built in this case was the small straight-girder bridge at Contich, over the Contich-Lierre line. A feature of this bridge is that the *fixed and sliding* supports of the girders on the abutments consist of *pre-cast concrete blocks with transverse reinforcement*, and is the *first* application in this simple case, of reinforced concrete bearers in place of the usual cast steel.

* * *

Bow-string girder bridges.

For spans of 35 to 40 m. (115 to 130 feet) a bridge with bow-string girders is an economical way of carrying a road over railway lines.

The most recent examples of this form of construction were built to suppress level crossings at Wavre-S^{te}-Catherine and Contich.

The bow-string girder is formed of a parabolic arch subtended by a *tie beam* in line with the edge of the flooring, the weight of which is transferred to the arch through thin hangers.

The complete theoretical definition of this girder would correspond to that of a Vierendeel girder. In this latter girder the uprights being subject to bending

should be splayed out where they join the arch and tie beam; as a compensation the stresses in the arch and the tie beam due to dissymetrical loading would be reduced. In short, a bow-string girder is the limit case of a Vierendeel girder with uprights with no rigidity.

Actually the hangers always having inertia in the plane of the girder are subjected to bending, and therefore may crack where built into the arch and tie beam. Such cracks do sometimes occur without, however, much danger to the structure.

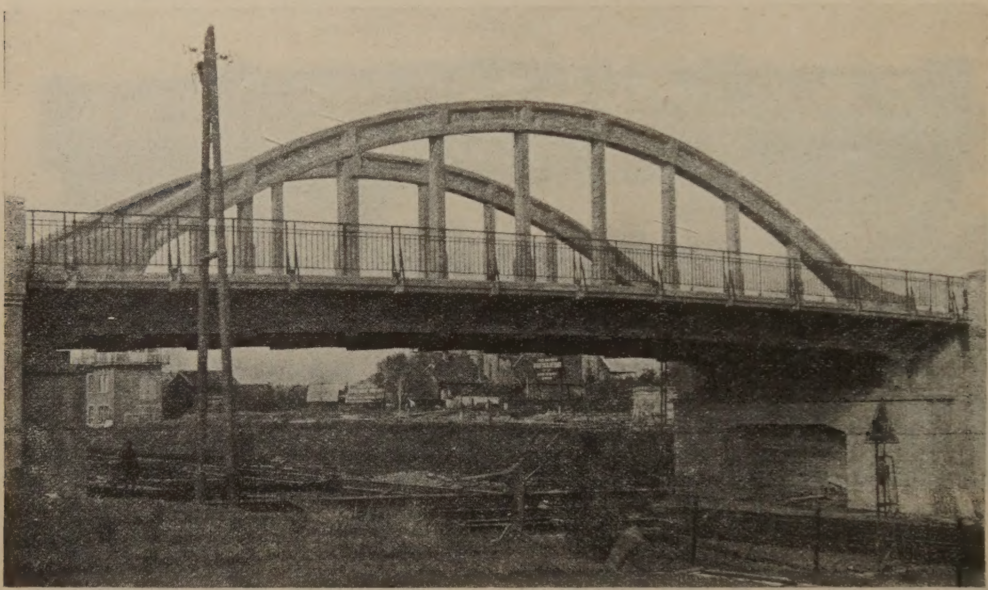


Photo 2. — Over-bridge at Contich.

As regards appearance, the thin hangers appear to be more elegant than the uprights of a Vierendeel girder.

The first bridges of this type were designed by Messrs. Considère of Paris, the arches being in hooped concrete of octagonal section.

It must be admitted that if the hooped octagonal section is the best under simple compression, it is not when the bending under dissymetrical loading and the transverse rigidity of the arch are taken into account.

This leads one to prefer a deep H section with wide flanges and a plain or lightened web.

The graceful Wavre-Ste-Catherine and Contich arches are box girders with solid webs. The Termonde arch representing the last example of the series, as pointed out before, is lightened out between the uprights.

The absence of upper cross bracing is a feature of these bridges. This has only been made possible by making the arch very stiff transversely and by the well designed junction of the hangers and tie with the arch. This junction is obtained by the reinforcement (cross girder — upright) being of inverted crutch form at the ends of the girders.

As regards the bearings, an interesting

innovation has been incorporated in the Wavre-S^{te}-Catherine and Contich road bridges on the new electric line, as in the earlier Ath, Manage, and Charleroi bridges. *Reinforced concrete rockers* have been used in place of the usual metal bearings with rollers. The mobile part consists of a concrete rocker reinforced by transverse bars in layers. The top and bottom bearing surfaces are *centered.* To prevent any local crushing through poor contact surfaces, thin sheets of antimoniated lead are inserted between the bearings and the rockers. The rockers were easily made and the cost is low. The actual finish of the contact surfaces was so good that the lead sheet was not really needed.

The construction of the abutments should be noted. Each abutment consists of two main pillars carrying the bearings, connected under the bearings and to the foundations by two cross bearing slabs forming a closed frame.

The fill is free to spread itself between the main bearing pillars.

* * *

Footbridges.

Several bow-string footbridges were built at Contich and Duffel of the type already described and used at Athus, and more recently at Meirelbeke.

The *bearings* of these extremely light bridges have been made in an ingenious and inexpensive manner by *articulating one of the bearing pillars so as to make it into a rocker of great height.*

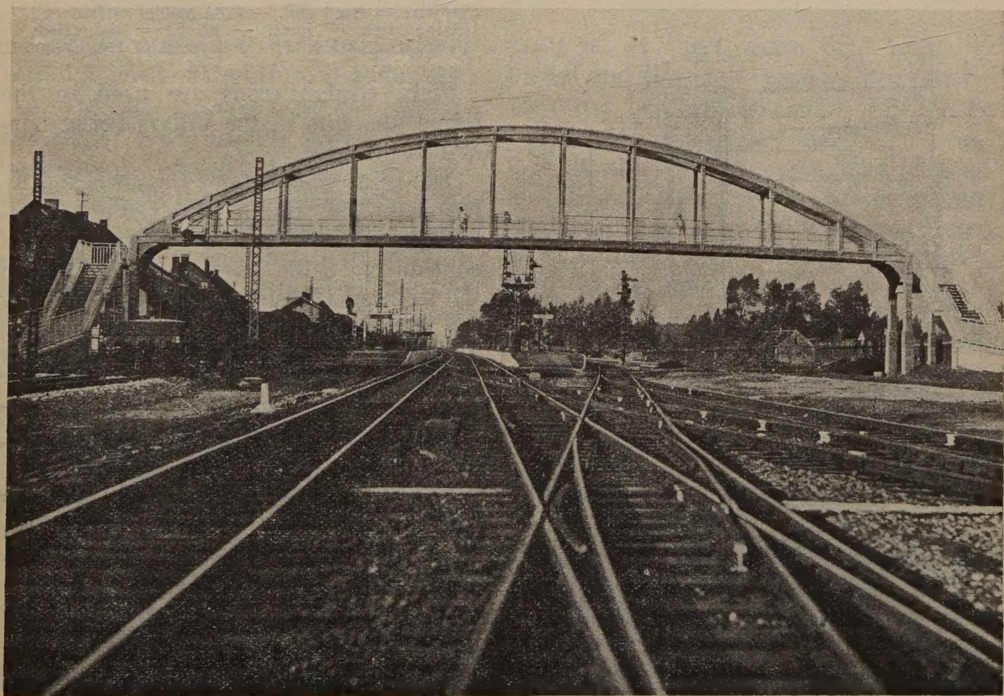
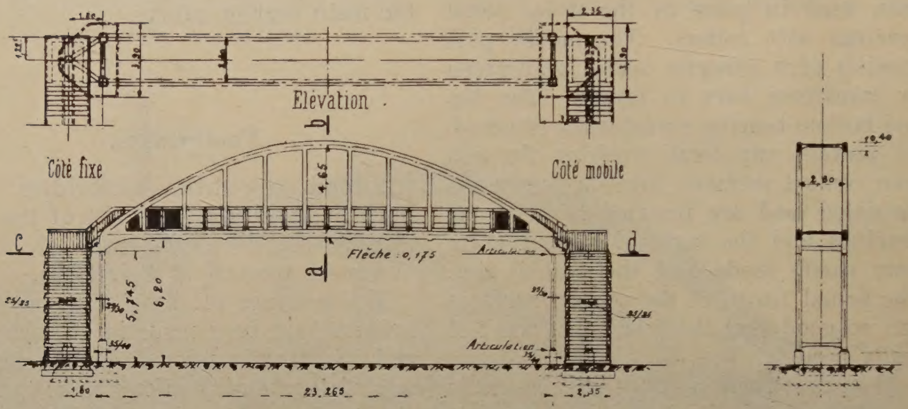


Photo 3. — Contich footbridge.

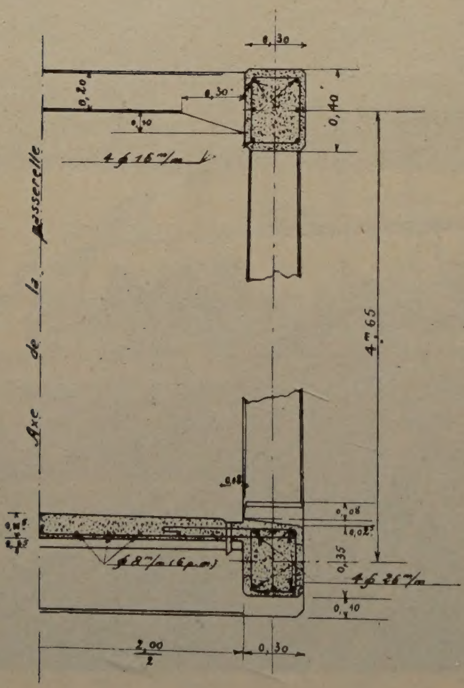
Fig. 1. — **Electrification of the Brussels-Nord to Antwerp line.**

Foot-bridge at No. 11 level crossing, Duffel.

Section along c-d. *Section along* a-b.



Section along a-b.



Explanation of French terms:

Côté fixe = fixed end. — Côté mobile = free end. — Articulation = joint. — Flèche = deflection. — Axe de la passerelle = centre line of foot-bridge.

Plain straight rods are used in the joints, the cuts in the pillars being normal to the axis.

The reinforcements of the arch and tie beams of the Duffel and Contich foot-bridges are welded together so as to get continuity of the bars of the arch and the tie beams, besides greatly simplifying the reinforcement. The main advantage of welding is not so much the saving of metal as the *more simple reinforcement.* There is no overlapping of the rods and *encasing of the reinforcement* is more easily and reliably carried out.

All these footbridges are cross-braced at the top.

* * *

Bridges with encased steel girders.

A number of over- and under-bridges have been built with the steel girders

Photo 4. — Foot-bridge.

encased in concrete, carried on partly or fully lightened-out reinforced abutments.

As regards *over-bridges*, the use of steel under roads can be justified when the depth of the floor has to be kept down. The local road authorities, moreover, insisted on the gradient of the approaches being less than 1 in 40. Under such conditions reinforced concrete floors could not be used as the cost of the approaches (land, embankments, and pavings) would have been too high.

The steel girders, usually with wide flanges, are encased completely or partially according to the span and the depth of the sections. The steel girder work is confined to the width of the roadway, the footpaths being carried on reinforced concrete brackets carried by the floor steel work.

The concrete abutments have been lightened considerably.

Bridges of this kind for spans up to 23.50 m. (77 feet) have been built at Duffel and Hove; the span of the Vieux-Dieu and Berchem bridges is smaller.

Although hardly germane to this article, it will be remembered that, during the recent alterations at Brussels-Nord Station, the bridge carrying the Avenue de la Reine over the railway was rebuilt with Grey girders 1 m. (3 ft. 3 3/8 in.) deep and upper slabs, part carried by the girder flanges, and part encased. The girders used had a span of 25 m. (82 feet), that is a ratio of depth to span of 1 in 25.

The use of girders with wide flanges is more justified when building *bridges carrying railway lines*.

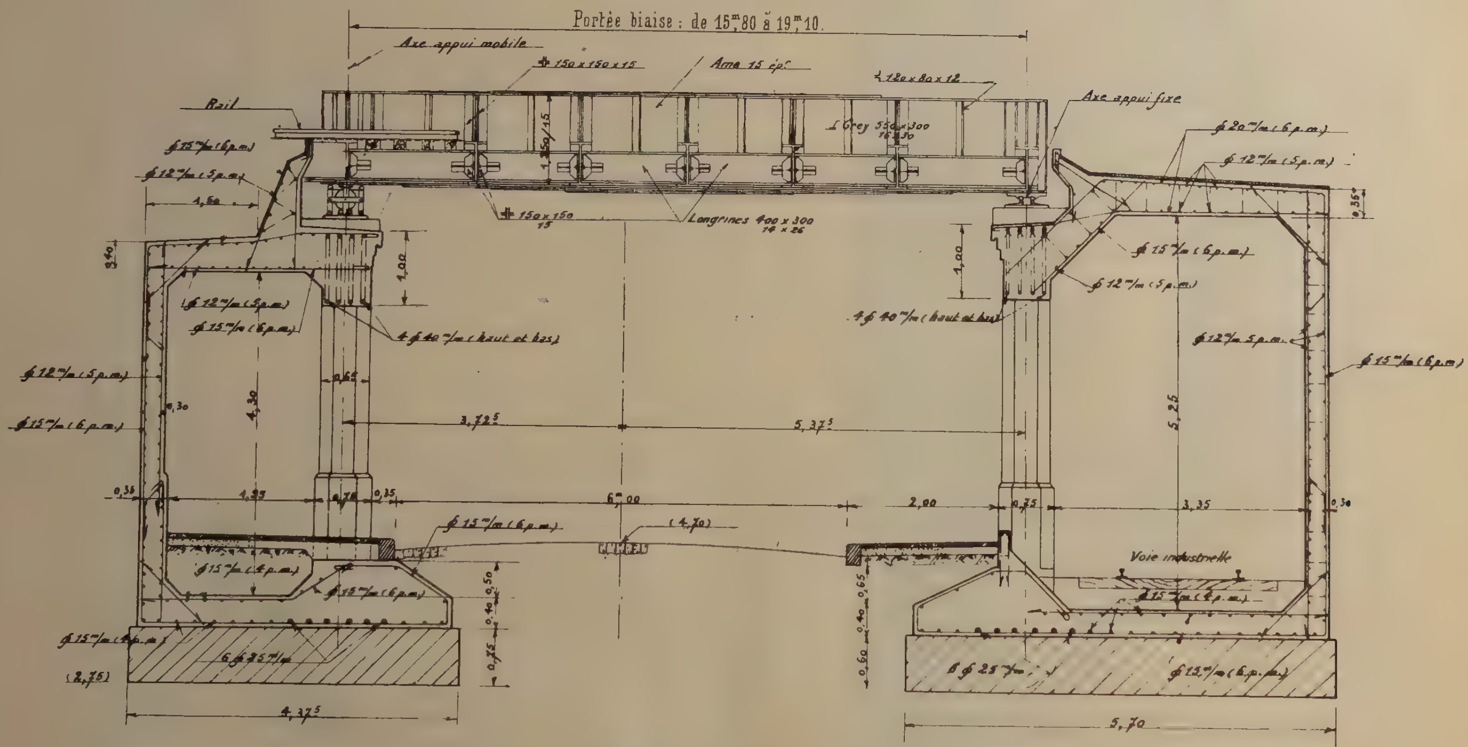
We would like to call attention first of all to the skew bridge built at the point where the electric railway is carried under the Liége line in Scharebeek station.

The skew, 16 1/2°, is so pronounced

Fig. 2. — **Electrification of the Brussels-Nord — Antwerp line.**

Under-bridge replacing level crossing No. 9, rue de la Station, Duffel.

(*Normal cross section.*)



Explanation of French terms:

Portée biaise = skew span. — Axe appui mobile = centre line of mobile bearing. — Axe appui fixe = centre line of fixed bearing. — Voie industrielle = works siding. — Longrines = stringers. — Haut et bas = top and bottom.

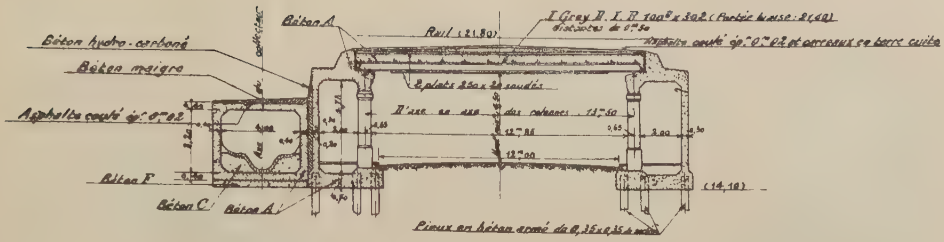


Fig. 3. — **Brussels-Nord to Ostend line.**

Railway bridge over the Avenue de la Reine, at Laeken.

Normal cross section.

Explanation of French terms:

Axe du collecteur = centre line of main sewer. — Carreaux en terre cuite = tiles. — Béton hydro-carboné = asphalt concrete. — D'axe en axe des culasses = between centres of abutments. — Asphalte coulé = sheet asphalt. — Béton maigre = poor concrete. — Pieux... armé = reinforced concrete piles. — 2 plats soudés = 2 flat bars welded together.

that a bridge with parallel girders on the centre line of the overhead track was impracticable. A bridge with parapet girders was also out of the question. A composite design therefore had to be used with girders at right angles to the lower track, carried in the angles by two box-section girders. The box-section girders consist of two Grey girders 1 m. (3 ft. 3 3/8 in.) deep, braced together by inside diaphragms and by plates on the flanges. These parts are welded together to form a girder of considerable cross rigidity.

The plain concrete abutments have been lightened considerably.

Another design of *under-bridge* has been used in a number of instances on the Antwerp line and at several other places on the System. The abutments consist of reinforced concrete tubes through which the footpaths run. The side of the tubes against the road is opened out into columns and top girders carrying the flooring built up of beams encased in concrete.

The advantages of this arrangement are :

1. The total width of the girder flooring is reduced as the abutments take the place of the footpaths.

2. The cost of the uneconomic mass of concrete in solid abutments is avoided.

3. Expensive foundations, on piles with doubtful subsoil, are unnecessary.

4. The span of the flooring is reduced, and encased beams can be used when the difference in level is limited. Experience has shown that the reduction in the span of the flooring can be of great advantage in certain cases.

If the available depth is very restricted, a shallow metal bridge can be used in place of the girder flooring.

The design with shallow metal flooring has been used on the Antwerp line for the under-bridge replacing the level crossing with the Liége road at Duffel, and the two level crossings No. 9 rue de la Station, at Duffel, and at Hove.

The bridge replacing the No. 9 level crossing at Duffel is unusual in that on one side the footpath is taken through the lightened-out abutment and at the opposite end a siding line to the rolling stock gauge. By running this line through the second lightened-out abut-

ment, the construction of an additional and costly structure was avoided.

The largest structure of this kind, i.e. with lightened-out abutments, is the one carrying the lines in *Laeken* station over the *Avenue de la Reine.*

This bridge is very much on the skew and by using Grey D. I. R. girders 1 m. (3 ft. 3 3/8 in.) deep, it was possible to cross a span of 21 m. (68 ft. 10 in.) on the skew over the 12 m. (39 ft. 4 1/2 in.) wide roadway.

The girders had to be stiffened by welding an additional flat bar to the flanges.

This is truly a limit case of the use of this design. The artifice of using lightened-out abutments enabled us to solve the problem with the levels specified, as otherwise a centre pier would have had to be used and would have altered the appearance of the structure entirely.

The essential factor if flooring of encased beams is to last, is the water-tightness of the casing. Belgian and foreign experience shows that in many cases the concrete cracks at the beams and water gets in. It is therefore inadvisable to count on the adhesion of the concrete to the metal work in the flooring of railway bridges.

* * *

Bridge over the Dyle at Malines.

Two brick arch bridges were built over the Dyle in the course of certain work carried out before the war on the Antwerp side of Malines. The foundations were carried on caissons driven by compressed air. When electrifying the fast lines, the crossing of the Brussels-Antwerp and the Brussels-Louvain fast lines had to be suppressed by carrying the former over the latter. Moreover, provision had to be made for raising the level of the Malines station in the future. These two conditions involved raising the level of the rails on the Dyle bridge (Muysen side) by some 7 m. (23 feet).

An entirely new bridge could have been built clear of the existing one, but instead of this costly solution it was decided to use the existing bridge and build a second floor on top of it. The new work had to be as light as possible so as not to overload the existing foundations whilst maintaining the existing state of equilibrium.

As built in reinforced concrete, the part carried on the arch is designed as a viaduct of several bays on thin piers supported by the old arch in line with the old transverse lightening walls.

These piers are tied together at the bottom by two strong reinforced concrete beams on the old wing walls.

These beams can act as braces or ties between the abutments according as to whether the thrust of the embankment or that of the arch is under consideration.

The lightened-out cellular-type abutments are continued backwards by return walls cantilevered from the main mass and tied by oblique reinforced concrete tie bars.

The old structure was strengthened in this way without the existing foundations having to be extended.

Bridge over the Nèthe at Duffel.

This bridge was rebuilt after the war and consists of a number of flat arches wide enough to carry the two railway lines.

The river piers have cutwaters on both sides, the top part of the pier spandrels being lightened by means of semi-circular lightening arches through the spandrels.

Photos 5-6. — **Bridge over the Dyle at Malines.**

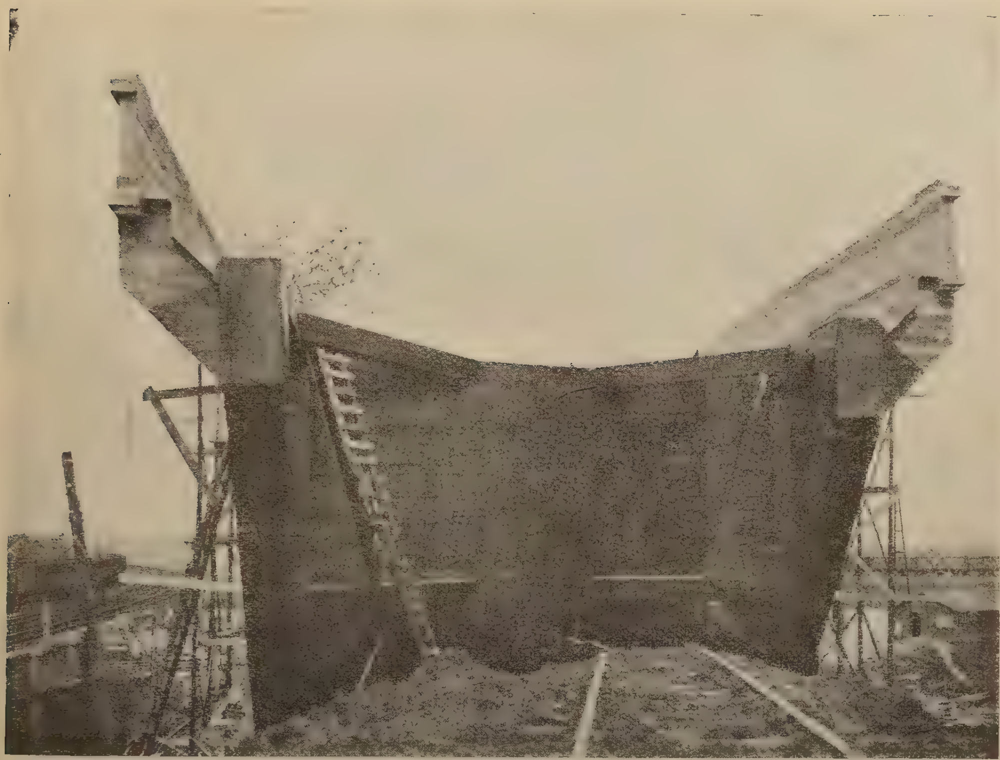


Photo 5.

Photo 6.

The whole structure was built of Boom bricks, the foundations of the piers and abutments being laid by compressed air.

It had been decided to double the number of lines in readiness for the electrification and this meant building a new bridge or widening the present one. A new bridge would have meant throwing over the new lines quite a large amount and the cost of building it to the existing arrangement and location of the lines would have been extremely costly. A cheaper and more easily carried out solution was to widen the existing bridge.

The problem was made difficult as only the cutwaters were available as additional supports.

The arches could not be widened and the piers for carrying the flooring could not be built on the existing cutwaters with safety. The lightening arches were thought of in due course. The empty spaces in the spandrels were used for a transverse straight strongly reinforced concrete beam carried on the ends of two reinforced cantilever brackets supported by the cutwaters. The flooring for a single-track line was carried on these girders on each side of the existing structure.

Photo 7. — Bridge over the Nèthe at Duffel.

The whole forms a strongly braced U beam, the bottom member being anchored by tenons in mortices in the haunches with its jambs resting on the cutwaters.

The arrangement of the reinforcement bars was given careful attention to ensure continuity of the bars, and to get a perfectly bonded unit, a *sine qua non* condition if the layout was to be stable.

The work was carried out under ordinary train working conditions; at no time was the traffic interfered with.

* * *

Retaining walls.

Very long retaining walls have had to be built for example at Malines station and on the lowered section of line from Hove towards Berchem. These walls have all been built in reinforced concrete with lightened sections as decribed in the article published in the *Bulletin* of No-

vember 1934. The following is a brief description of these walls :

Retaining walls used to be plain concrete or brick in nearly all cases. Sometimes, when the height to be made good was great, the section was lightened out and the wall built as a blind viaduct in masonry, the earth being allowed to move freely over the natural slope inside the arches.

Reinforced concrete walls were tried before the war but were not satisfactory owing to lack of experience. The question was reconsidered in connection with the important programme of new works the Belgian National Railways Company had to carry out and several profiles were developed with success.

The simplest section is a T section with a vertical wall holding back the ground and a base slab sunk in the ground so that only the vertical wall is visible. This slab is built up of a back slab, the load on which is the thrust of the ground and a forward projection giving the extension necessary to distribute the load over the foundation subsoil properly.

The vertical wall usually is given a slight batter on both faces so as to improve the section as it approaches the foundation slab.

This wall section is a cheap one and has been used up to a height of 3 m. (9 ft. 10 in.).

When the height of the embankment is greater it is cheaper to lighten to a greater extent the solid portion of the section and modify it on the lines of the usual form of ferro-concrete structure, using thin reinforced concrete slabs and ribbed girders.

The normal section consists of the counterforts with their horizontal connecting girders — shelf edge, end girders of base slab — connected together by a thin vertical wall and horizontal bottom slab.

The counterforts are spaced about 3 m. (9 ft. 10 in.) apart. They complicate the shuttering and reinforcement. From the point of view of economy in the construction, the T section should be used to the greatest height possible so as to reduce the function of the counteforts to that of stiffeners of the screen wall.

Such walls, as at Malines, etc., are much cheaper than plain or arcaded walls and have been built on soil of only medium consistency on which the older types of wall should have involved costly piling.

* * *

Metal railway bridges at Malines.

The new elevated electric lines in passing through Malines station cross the Louvain-Malines canal on the Brussels side of the station and, on the Antwerp side, the Muysen line and the Louvain road on two double-track steel bridges of about 63 m. and 90 m. (207 and 295 feet) span respectively.

These bridges are parapet-girder bridges of the Vierendeel type, the girders of the 90-m. span being identical with those used in the double-track bridge recently built over the Albert Canal at Herenthals.

General description.

Flooring.

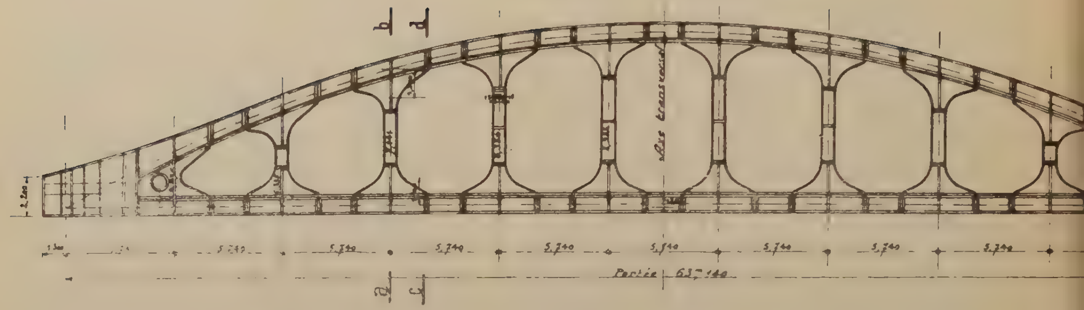
The floor properly speaking — stringers and cross beams — of the different bridges has been designed on the same principles.

An essential requirement in a bridge

Fig. 4. — **Bridge**

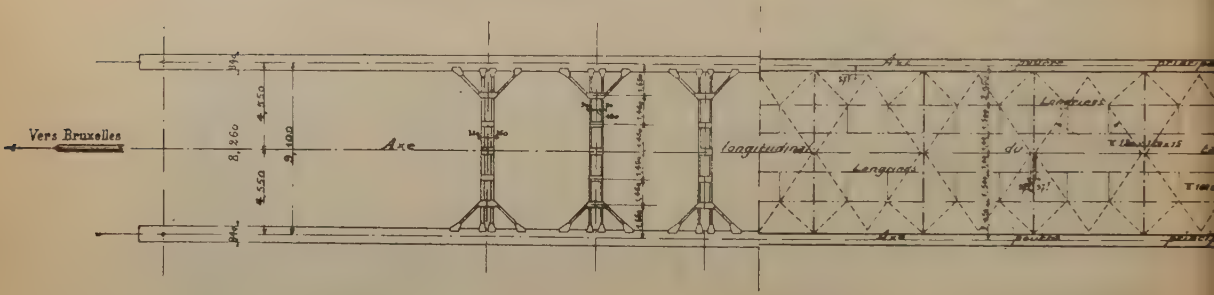
Metal bridge of 63.14 m. (

Elevation of main girder.

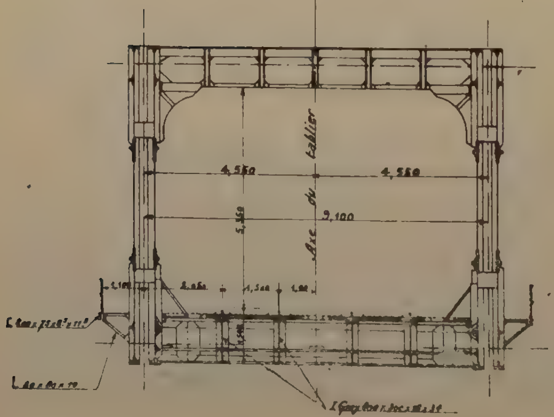


Half upper wind bracing.

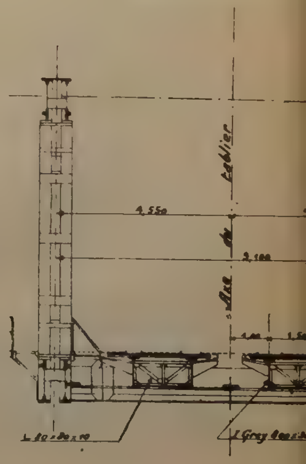
Half diagrammatic plan of



Cross section along a-b.



Cross section alon



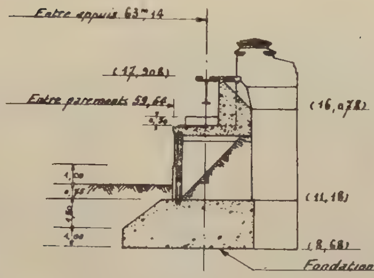
Legend :

nal at Malines.

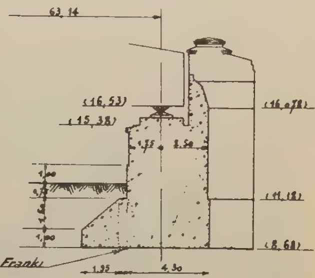
pan (Vierendeel girders).

Abutments.

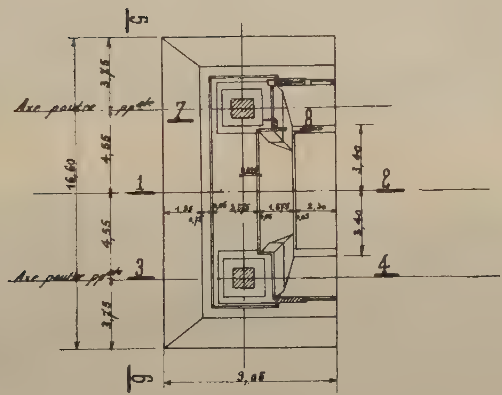
Section along 1-2.



Section along 3-4.

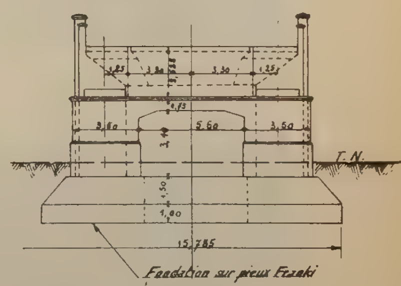


Plan view.

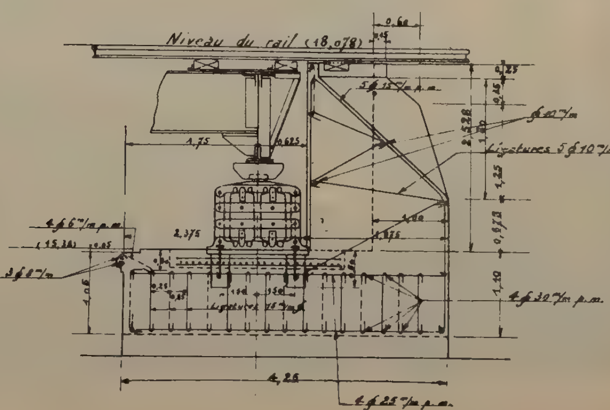


cing.

Elevation on 5-6.



Section along 7-8.
Footing and bank retaining wall.



dinal girders.

vind bracing.

Explanation of French terms:

Portée = span. — Axe longitudinal du tablier = centre line of bridge floor. — Longrines = stringers. — I Grey = Grey girder. — Entre appuis = between bearings. — Entre parements = between facings. — Axe poutre ppale = centre line of main girder. — Fondation sur pieux Franki = foundation on Franki piles. — Niveau du rail = rail level. — Ligatures = binding wires.

Photos 8-9. — **Vierendeel railway-bridge over the Louvain road at Malines.**

Photo 8. — General elevation.

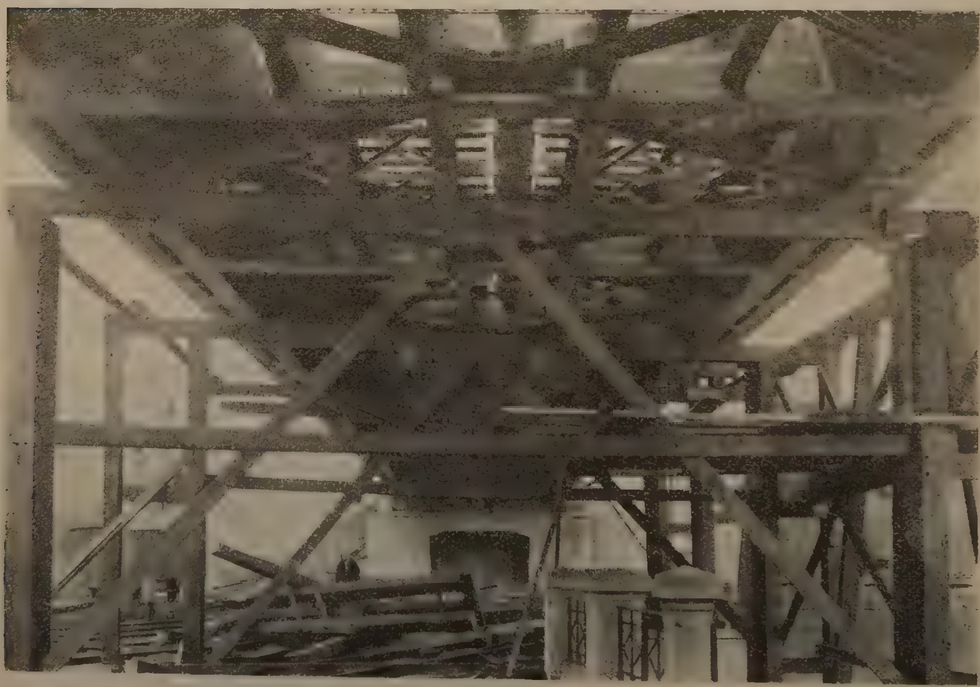


Photo 9. - View of flooring and bottom cross bracing.

carrying railway lines is to make the floor which directly carries the track, as rigid as possible. The depths and dimensions of the various parts are designed to give the maximum rigidity rather than as regards the maximum stresses. Experience shows that the best ratio of height to span of these parts lies between 1 : 5 and 1 : 6.

Another practical rule is to build up these parts from simple rolled H joists instead of building up the girders from small parts, thereby obtaining the most robust and durable section. The most suitable sections are obviously I sections with wide flanges. The usual result of following this method is that the girder, even under the most unfavourable conditions of loading, is stressed much below the limiting value. Both theory and practice prove that the stresses in girders under the dynamic efforts set up by the moving loads can exceed the calculated values very appreciably. The excess of metal which at first sight appears unnecessary, i.e. when designed by calculation, is justified in practice by the actual stresses existing in the members.

It should be noted, moreover, that the cross girder with its gusset plates and the uprights form a cross frame, the rigidity of which is an essential element in the stability of a railway bridge. As this condition would be best met if the cross girder were infinitely rigid, it is easy to understand that the latter should be made the greatest depth possible.

The stringers and cross girders are assembled by connecting together the top flanges by large gusset plates, building these details into one another and converting the floor into a multiple series of boxes with the parts solid with one another. This arrangement makes the cross girders extremely strong as regards longitudinal forces and makes the special bracing known as « braking » unnecessary. This bracing which consists of providing fixed stops to take the thrust of the flooring on the lower members is generally used on German bridges with hinged joints.

The Vierendeel girders of the Herenthals and Malines bridges have the common characteristic of a flattened 1 in 7 parabolic arch with 11 panels. The same numerical data could be adopted in all the calculations. These girders have all their details boxed in. The space separating the two parts is wide enough to allow a man to get in to do any repairs required.

As bending moments in both directions have to be absorbed, H sections had to be used. These sections are built up in the usual way from angles and flats. In the case of the double-track 90-m. (295-ft.) bridge, special angles with 180 mm. (7 3/32 in.) wide flanges had to be used.

The tables of the Herenthals and Malines booms, as in the ordinary boxed-in lattice girders, are placed on the outside.

As, however, these overhanging tables are necessarily wide, they are held between two angles fastened to the web; the free end is secured to its web by angle brackets to obviate any tendency to buckling.

The uprights fit into the open box-shaped arch and tie quite naturally and form an exceptionally rigid framework. The uprights are built in near the heel of the brackets connecting the uprights and the booms. Their exact position depends upon the maximum width of the gusset plates (some 3 m. = 9 ft. 10 1/8 in.).

The web of the uprights, except joints, is continued to the full height of the girder.

The brackets connecting the uprights with the members have angles along the edges offset to clear the edge angles of the arch and the tie. This offset is required for erection purposes.

The sections of the arch and ties are continuous from end to end of the girder. This arrangement is justifiable when it is appreciated that the whole forms a single bow-string girder under continuous full load.

Bottom wind bracing.

This bracing has to absorb in addition to side wind pressure on the lower part of the bridge, the stresses due to nosing and other horizontal forces which may be set up.

The diagonal ties form a lozenge secured to the middle of the cross girders and of the panels of the lower member between successive uprights. They are securely fastened to the lower flange of the stringers by gusset plates. The lozenge is completed by angles joining these gusset plates to the four tops of the panels formed by the cross girders and the booms.

The resulting structure is extremely rigid.

Top wind bracing.

The arches of the Vierendeel girders have a very wide margin of safety against general buckling between supports. The upper bracing has been reduced to light details which make the robustness of the main arches the more noticeable. In its essentials it consists of transverse overhead gantries in light trellis between the uprights; the top member of this bracing with plain uprights with an angle tie but without diagonals resembles a Vierendeel girder with parallel members.

Along the outer face of the arches these gantries form a series of uprights connected to the arches by angle braces. This gives this centered girder the appearance of a Vierendeel girder and leaves large clear spaces between the arches so that the spectator no longer has the impression of the usual confused tangle of cross bracings.

Bearings.

The bearings used include certain new features.

Fixed bearings. — The fixed bearings consist of a lower seat with a pad as cast and a machined convex bearing surface in place of the usual cylindrical hinge.

The upper rocker has a flat bearing surface resting like a cap on the lower seat through which the load from any direction is transferred to the masonry under it.

Mobile bearings. — The mobile bearings consists of two segments with cylindrical bearing surfaces of large radius. These segments are capped by a fixed centering rocker similar to a fixed bearing. The segments rest on a bearing plate. The upper rocker, the segments, and the lower plate are connected by a double set of parallel links.

The principles followed in designing these bearings were :

1. Reduce the number of segments to two, to make sure the bearing pressure between the two parts is equally distributed;

2. Make the segments as large in diameter as possible to get great sensitivity;

3. Get a reliable and continuous connection between the mobile bearing and the bridge under temperature changes.

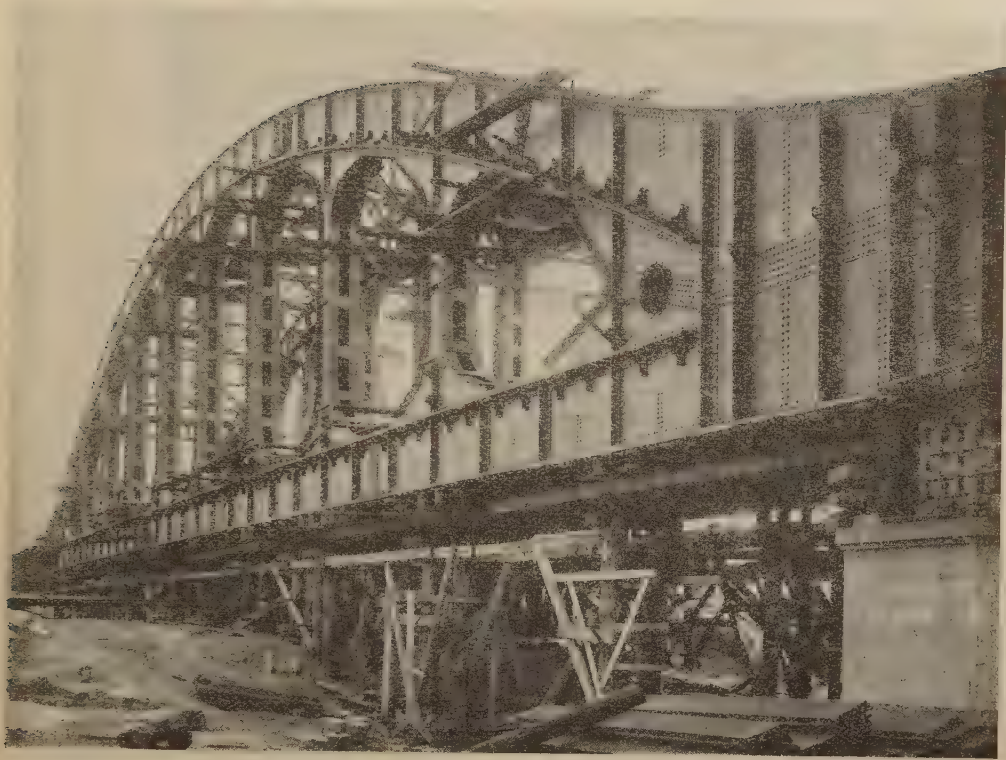


Photo 10. — Vierendeel railway bridge. — Mobile bearing.

Loadings.

I. The axle loads have been increased to 25 tons to take future developments into account. In the typical train, the heaviest load is given by 5 pairs of wheels at 1.50-m. (4 ft. 11 in.) centres.

II. The dynamic augment due to the moving loads has been calculated by one of the recognised formulæ.

The difficulty of accurately calculating the coefficients of dynamic augment was brought out in an article published in the *Annales des Ponts et Chaussées de France*, 1932.

In the absence of anything better the ordinary formulæ have to be used. In this respect, however, the Vierendeel girder could be considered as behaving like a plate girder rather than as a lattice girder. The strength of the uprights and the extensive widening of the plate at the junctions with the booms justify this opinion. Then too, the absence of diagonals subject to alternating stresses must be considered as removing from the girder one particular source of dynamic variations.

Calculations.

The main girders have been calculated by the simplified method given by Mr. Vierendeel in his lectures on the stability of structures.

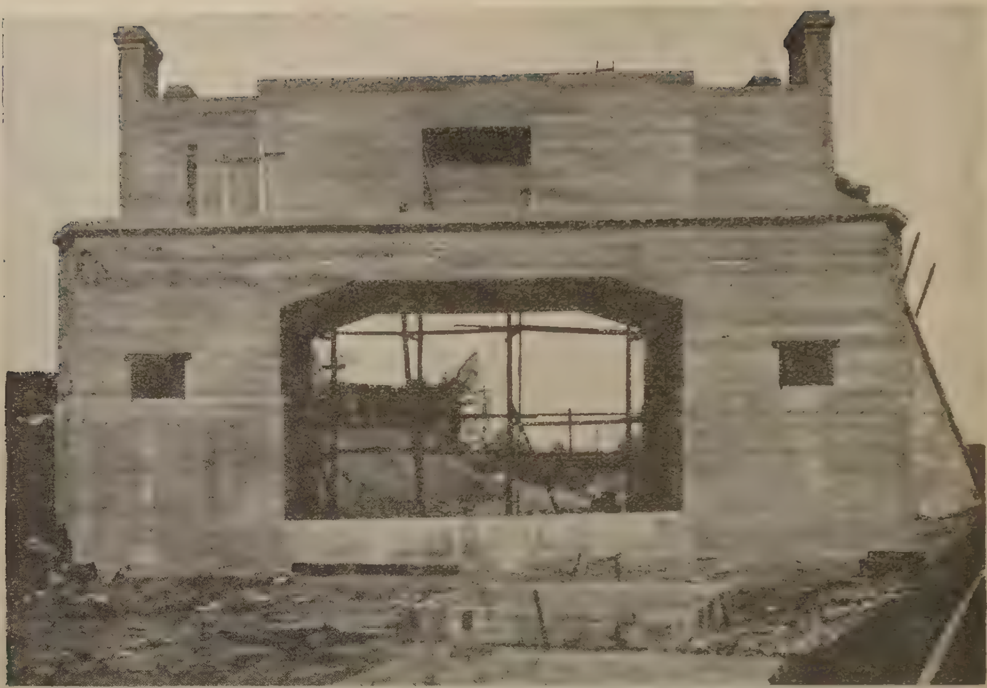


Photo 11. — Railway bridge over the Louvain road at Malines. — Abutment.

Tables and diagrams giving for each joint under load the values of the horizontal reactions at the point of inflexion of the uprights and the bending moments in the boom and uprights have been prepared. These values are directly applicable to girders of like proportions (flatness of arches and number of panels).

If the girder be considered uniformly and fully loaded, the load on the arch becomes a simple compression along its axis, the tie itself being uniformly stretched between the bearings. Under these loading conditions, the uprights are simply loaded in tension by the weight of the flooring.

It is interesting to note that in the central triangular sections of the members, the constraining forces under the hypotheses of full load are greater than those caused by partial loads. These latter would only be less favourable in the brackets connecting the uprights and members, when taken as triangular.

On the other hand, the stresses in the uprights can only be defined in flexion when under partial loads.

General remark.

Without starting a new debate on the theoretical advantages of the Vierendeel girder, it should be noted, however, that the girders of the Malines bridges are exceptionally rigid when their actual design is considered.

[625. 26 (.493)]

An up-to-date spring shop,

by L. BERTRAND,
Engineer, Belgian National Railways Company.

Until quite recently each workshop of the Belgian National Railways Company repaired the laminated springs on the locomotives, carriages, and wagons it maintained. This method of working had the advantages of reducing carriage, and of making the workshops self-contained, but had the result of scattering the equipment, tools, and labour.

When the work carried out in these spring shops was investigated, it was found that the methods of manufacture differed from shop to shop, that the products were frequently below the required standard, and in particular that the heat-treatment was often unsatisfactory.

When the question was thoroughly gone into it was found necessary, if good products were to be obtained, to replace the old open hearths by special furnaces properly heated and automatically controlled and to install bending and hardening plant; it was also found necessary to provide means for testing, during manufacture, the materials, the temperatures, the dimensions, and the shapes, as well as the strength of the springs.

It was immediately evident that the spring shops should be centralised in view of the high cost of the special equipment of an up-to-date shop.

Special care was devoted to the question of furnaces as the fuel used must be such that the temperature can be regulated within narrow limits.

Now, the wagon repair shop at Cuesmes happened to be close to a coal distillation plant from which gas of sufficiently high calorific value could be obtained at a reasonable price. This proposal, moreover, obviated the provision of gas generators, gasometers, etc... with their costly maintenance.

Moreover, the Cuesmes shops repair a large stock of wagons and some buildings were available which were suitable for use as a spring shop.

The Cuesmes plant is now completed; the shop has been in regular use for more than a year.

As all railways are concerned in this matter, it was felt that a description of the methods introduced by the Belgian National Railways Company would be useful.

***

As already mentioned the Cuesmes spring shop has to repair the whole of the laminated springs on all the locomotives, passenger vehicles, and goods wagons of the Belgian National Railways Company.

When the shop was designed, the rolling stock consisted of :

3 800 locomotives, with 50 000 laminated springs;

9 500 carriages and vans with 75 000 laminated springs; and

120 000 wagons with 500 000 laminated springs, i.e. a total of 625 000 laminated springs.

The length of the spring plates varies

from 180 mm. (7 3/32 in.) to 2 300 mm. (7 ft. 6 9/16 in.), and the section from 76 × 9 mm. (3 in. × 3/8 in.) to 160 × 16 mm. (6 5/16 in. × 5/8 in.).

The shop was designed to repair 300 springs a day.

***

The layout of the shop is shown in figure 1 and consists of the following main sections :

A — Gas-meter house.

B — Shop for preparing both new and recovered plates and buckles.

C — Spring shop proper, including a section in which the springs are taken apart, the hardening furnaces, the bending and hardening plant, the tempering furnace, and the assembling section.

***

The following is a list and a brief description of the machinery in each of these sections :

A. — *Gas-meter house.*

Coal gas is used exclusively by the spring shop furnaces.

This national fuel was selected as no stock has to be kept and all handling is saved; it involves a gas-meter installation comprising the various apparatus housed in room A (fig. 1). A general view of this room is shown in figure 2.

The principal characteristics of the gas supply are :

a) Calorific value measured on the Junkers calorimeter at 0° C. (32° F.) under a pressure of 760 mm. (29.9 in.) of mercury should average 4 250 calories (1 730 B. T. U. per cubic foot) with an hourly tolerance of ± 5 %;

b) Supply varying up to 15 000 m^3 (530 000 cu. feet) per day;

c) Incoming pressure between 350 and 5 000 mm. (13.8 to 196.8 inches) of water.

The gas-meter house consequently has to contain the following equipment :

a) Apparatus for keeping the furnace burners in working order :

— dust filter (see No. 1 of general layout, fig. 1);

— safety regulator (2) preventing any gas from being delivered at a pressure outside the limits laid down;

— pressure-reducing regulator (3) to bring the variable pressure at which the gas is received down to the constant pressure required by the burners;

— pressure raisers (5) to raise, if need be, the pressure of the gas as delivered to the required working pressure.

b) The meters according to which the supplier's invoices are prepared and by which the conditions of the contract are checked :

— calorimeter (40);

— thermometer;

— barometer;

— pressure meters (38) on the arrival main, and another beyond the pressure raisers;

— Connersville totaliser meter (4);

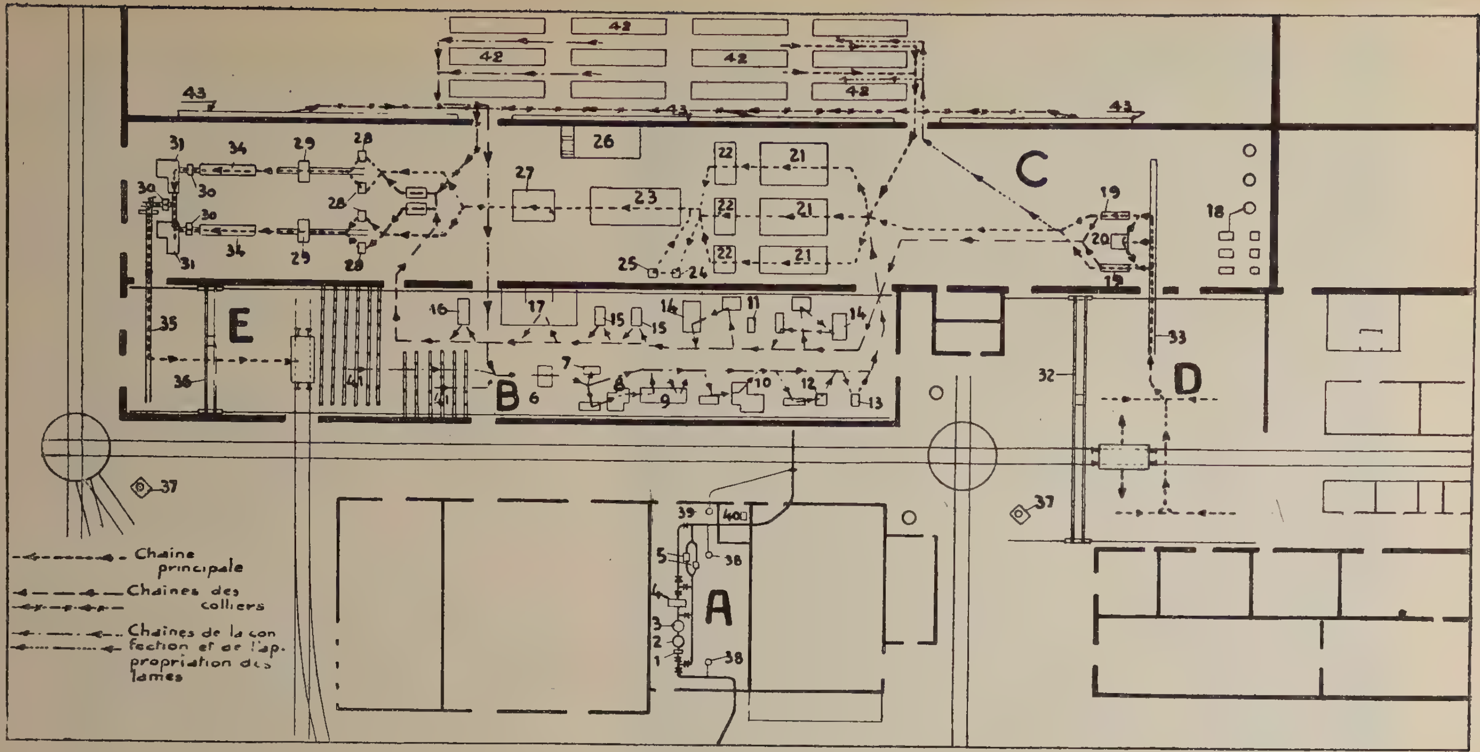
— and flow meter (39).

All this equipment is self-recording.

By-passes are provided on the mains so that the pressure regulator, meter, or pressure raisers can be avoided.

With the exception of the valves for these by-passes the whole of the equipment is automatic.

The most important indications of this apparatus such as the rate of flow at any moment and the pressure are repeated in the shop itself, in conjunction with au-



LEGEND.

A. Gas meter house.
B. Preparation shop.
C. Spring shop.
D. Springs awaiting repair.
E. Spring stores.

1. Filter.
2. Safety regulator.
3. Pressure reducer.
4. Meter.
5. Compressors.
6. Cold press.
7. High-speed emery grinder.
8. Roll.
9. Multiple plant.
10. Machine for rolling up ends.
11. Press for forging ridged plate ends.
12. Press for ribbing the plates.
13. Drills.
14. Hammers.
15. Slotting machines.
16. Puncher-slotter.
17. Electric welding plant.
18. Hydraulic pumps and accumulators.
19. Machines for pressing off buckles.
20. Buckle heater.
21. Hardening furnaces.
22. Hardening plant.
23. Tempering furnace.
24. Polishing machine.
25. Hardness testing machine.
26. Laboratory.
27. Setting springs.
28. Tipping plate presses.
29. Presses for tighteningu up the buckles.
30. Pneumatic lift.
31. Testing machines.
32. Overhead travelling crane for unloading purposes.
33. Runway.
34. Gravity roller conveyors.
35. Mechanical conveyor.
36. Overhead travelling crane.
37. Capstans.
38. Pressure meters.
39. Flow meter.
40. Junkers calorimeter.
41. Steel bar racks.
42. Spring plate racks.
43. Buckle racks.

Fig. 1.

Explanation of French terms:

Chaîne principale = Main belt. — Chaîne des colliers = Buckle belt. — Chaîne de l'appropriation... = Belt for manufacture and preparation of plates.

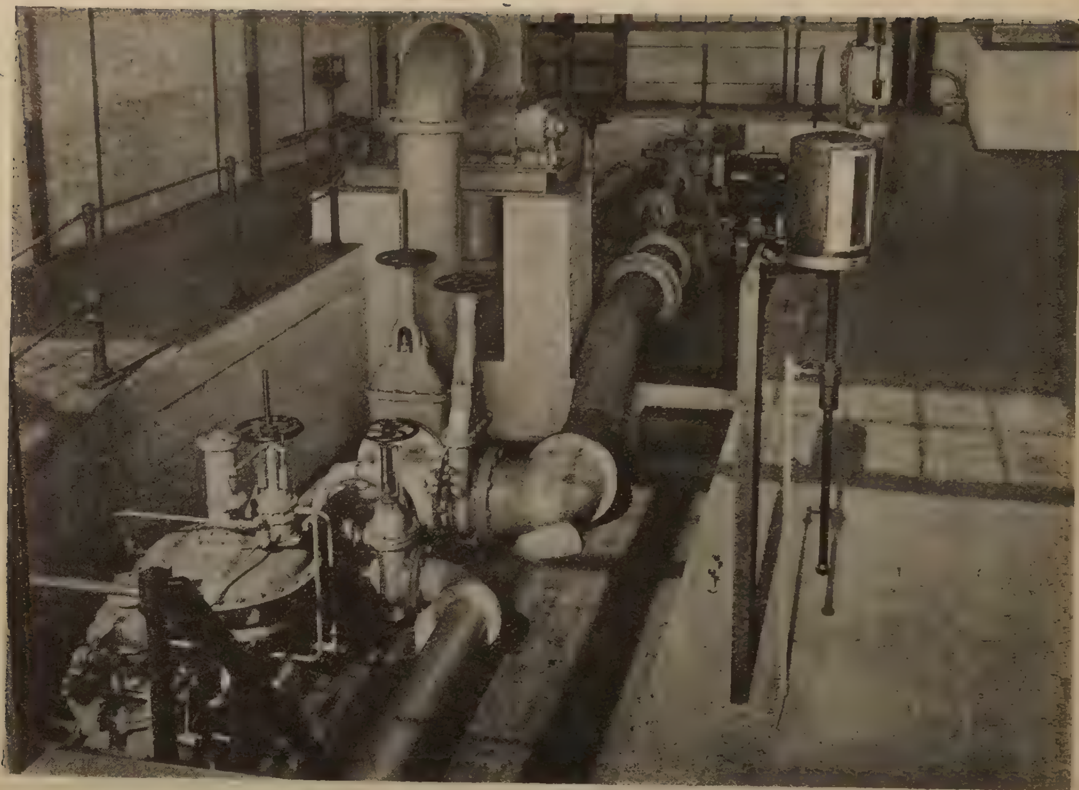


Fig. 2.

dible and luminous warning devices for the critical pressures.

The room is well ventilated; as the pressure raisers are driven by encased motors which are controlled from outside the room, enclosed electric lights are used, and the calorimeter is isolated, the danger of fire is reduced to a minimum.

Nobody except the management and the men responsible for the furnaces is allowed into the room.

B. — *Preparation shop.*

A general view of this shop is given in figure 3.

The machine tools are located so as to reduce handling to the minimum and to avoid cross movements.

The following machinery is provided for work done on the plates cold :

a) A 300-ton press (6) for cutting up the plates, punching the end holes, and cropping the ends of the plates to the various designs used, or

b) Drill machinery (13) for drilling plates assembled with a central rivet.

The operations done hot are many and varied. The tools used are mentioned below and are used for :

— preparing the re-used plates : multiple machine (9);

— thinning down the plate ends : plate roll (8);

— rolling up the plate ends : eye forming machine (10);

— making the ridged plate ends : hydraulically-controlled forging press;

— pressing in centre nibs : self-centering nibbing machine.

Fig. 3.

Furnaces with the front divided into a number of openings, to take a number of plates for heating over a short length at the same time, have been installed in the most convenient positions for feeding the machine tools enumerated above.

The buckles are repared in the same shop by means of two electro-pneumatic hammers (14) each with its own heating furnace, three slotting machines (15) and three electric welding plants (17). All this equipment is fitted with individual electric drive.

C. — *Manufacturing shop.*

The hydraulic machines installed in the shop are supplied with high-pressure water from the mains kept under pressure by three reciprocating pumps and three accumulators (18).

The first machines on the high-pressure main are two presses for removing the buckles (19) assisted in the case of badly rusted buckles by an electric buckle-heater (20).

The plates and buckles are minutely inspected as soon as the springs are stripped down, piece by piece, to see if they can be used again (fig. 4).

The repair of buckles is put in hand straight away and the plates fit to be used again are got ready (brought to length, centre nib regauged, the ends

thinned down) for subsequent heat treatment.

The heat treatment equipment is located in the centre of the shop.

Three hardening furnaces (21) with a useful hearth width of 1.70 m., 2.30 m. and 2.80 m. (5 ft. 7 in., 7 ft. 6 9/10 in., and 9 ft. 2 1/4 in.) and 5.70 m. (18 ft. 8 7/16 in.) width are arranged parallel one to the other.

Each of these furnaces is heated by ten burners using high-pressure gas, the air required for combustion being drawn through openings which can be

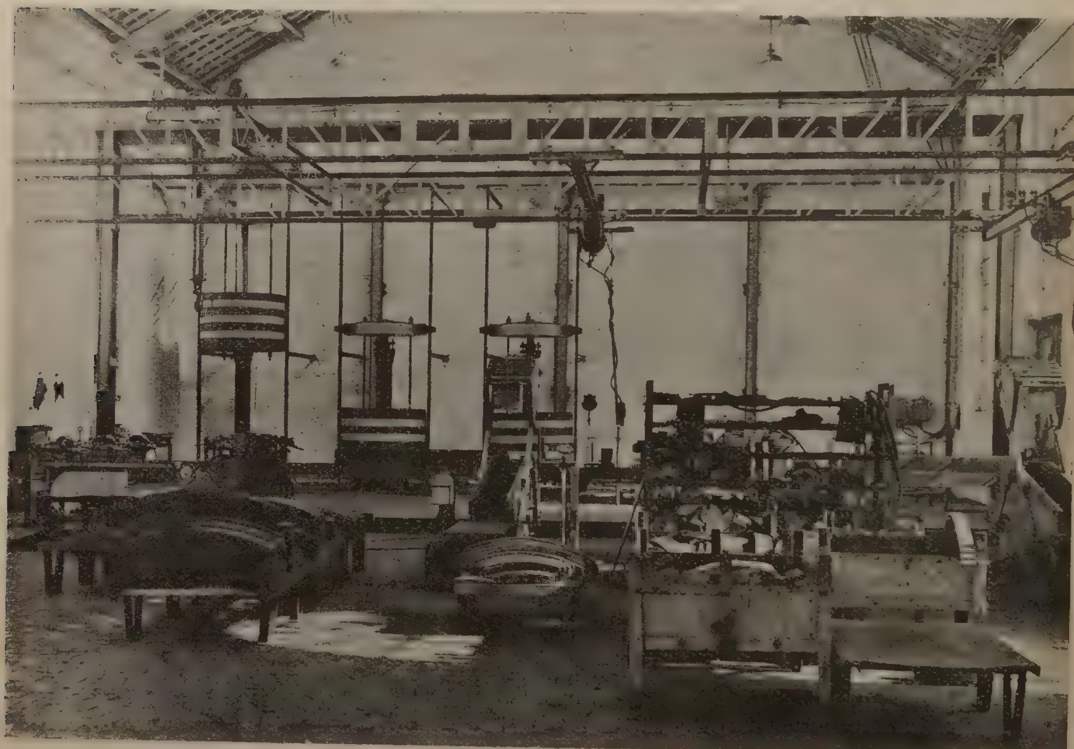


Fig. 4.

adjusted as required; there are consequently no air mains.

The products of combustion pass to a chimney, the draught of which is controlled by a set of dampers in the hearth.

This hearth is arranged in a special way (see fig. 5) so that curved plates can be handled.

As a matter of fact, the furnaces are fitted with jiggers by means of which the plates are fed forward automatically on the flat.

These jiggers pass under the hearth and then collect the full load of the furnace and carry it forward progressively to the outlet.

The longitudes of the jigger consist of two iron tubes which are cooled by cir-

culating water through them; they are covered with refractory bricks.

The speed of rotation of the mechanism is adjustable so that the springs to be hardened can be heated right through whatever their thickness.

Each hardening furnace is followed by a spring bending and hardening plant (22) (fig. 6*a*).

On leaving the furnace the plate is taken by a mechanical transporter which in minimum time puts it on the table of the bending machine, fig. 6*b*.

The three bending and hardening plants are automatic.

The plant is started up automatically by the plate moving past a given point.

This method has been introduced to withdraw the cooling off of the plate from the personal influence of the man operating the bending and hardening plant; such cooling has been reduced to the minimum.

Laminated springs fitted with bearing studs are set to the required curve and act as master plates; the plates to be hardened are pressed to suit, using the laminated springs as a flexible former, the pressure being maintained during the revolution of the system.

The movements of the laminated formers are interdependent: as the ram outside the tempering bath closes, the one immersed opens and thus releases the spring plate which has been bent and hardened, the two operations succeeding each other at close intervals.

Each revolution of the machine ejects the plate tempered during the previous revolution.

The retempering furnace (23) has a double roof and the metal floor sections forming the hearth are attached to two endless chains (fig. 7).

The rate of movement can be varied

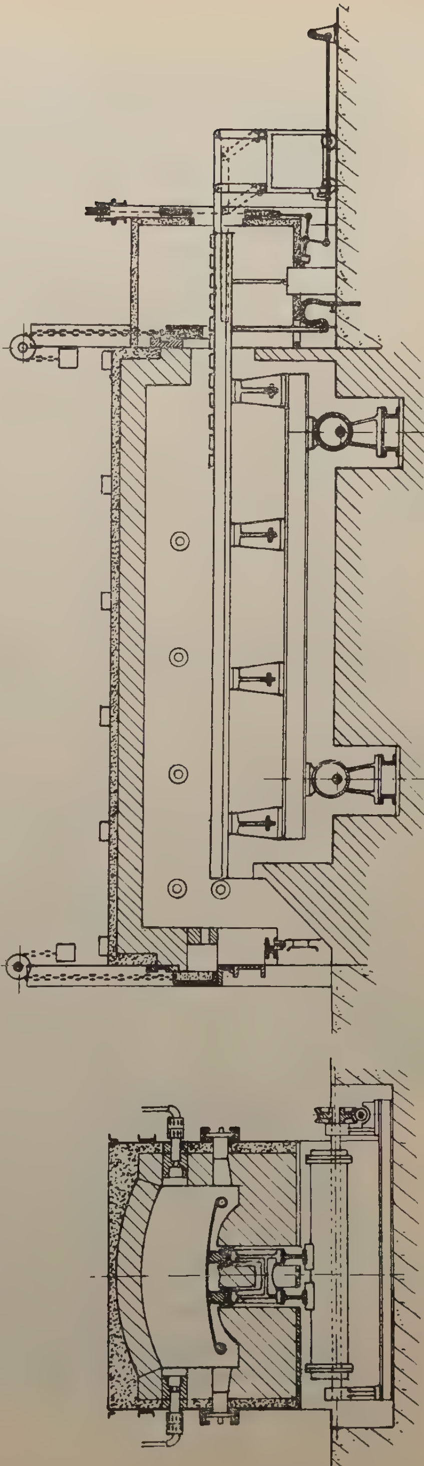


Fig. 5.

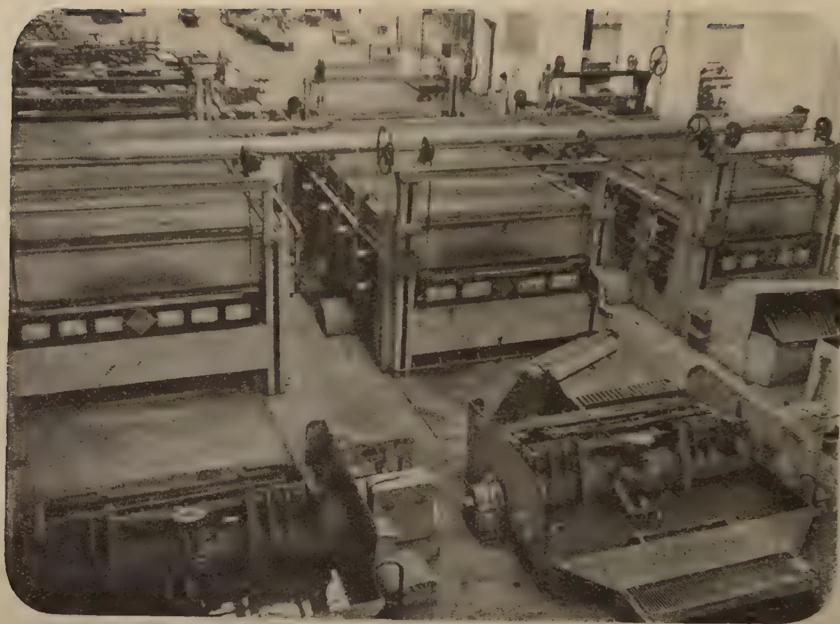


Fig. 6a.

Fig. 6b.

as in the case of the hardening furnaces; the length of the furnace is 6.70 m. (22 feet), and it can handle up to 2 500 kgr. (5 500 lb.) an hour.

Most of the plates which pass through the hardening plant have a perfect camber. The remainder are adjusted when heated for tempering, any deformation which has occurred during the heat treatment being corrected at the same time.

From the time the plate is put into the furnace for hardening, the unit dealt with has been a single plate; the plates, after being set, are put together ready for final assembling.

All the springs — or practically all — have solid buckles.

Fig. 7.

After being coated with a mixture of vaseline and graphite, the plates nipped together and the buckles, previously heated in small special furnaces (fig. 8) are put on hot in revolving hydraulic vices (28), through which the plates are held on a slope, so that the buckle can slide more easily towards the centre. The pressure is not released until top and bottom buckle plates have been put in place.

The buckle, after being accurately centred, is then press-fitted, while still hot; the press can develop 80 tons.

Two presses of this kind (29), with an encased bed, and equipped with a ho-

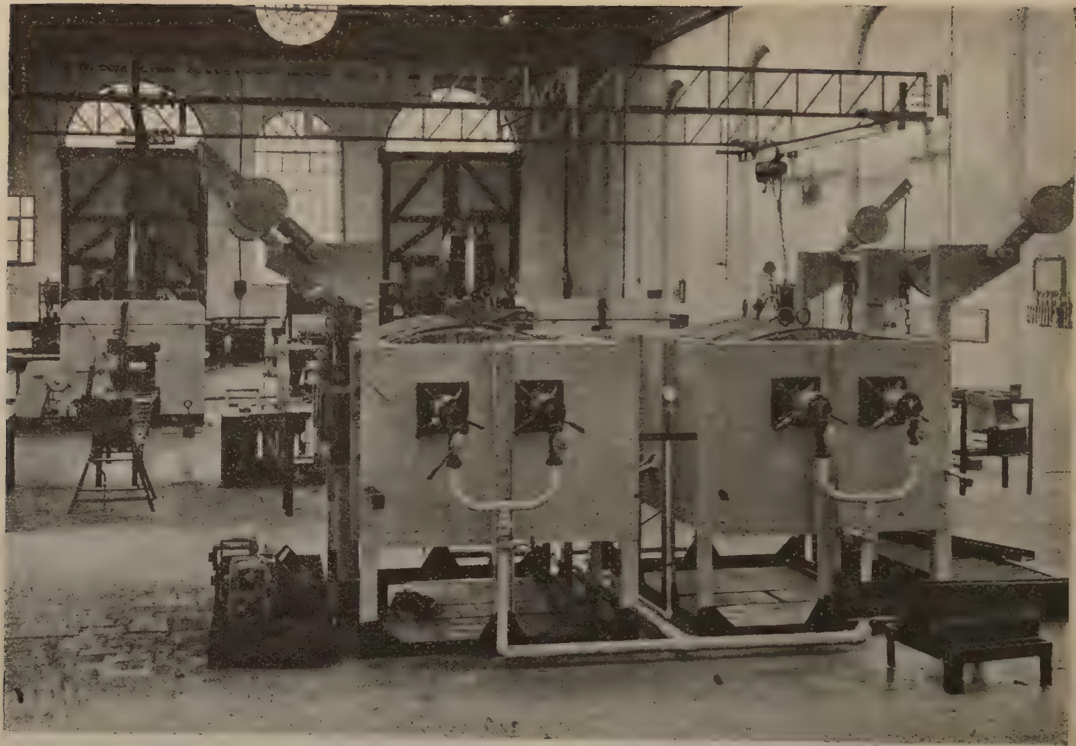


Fig. 8.

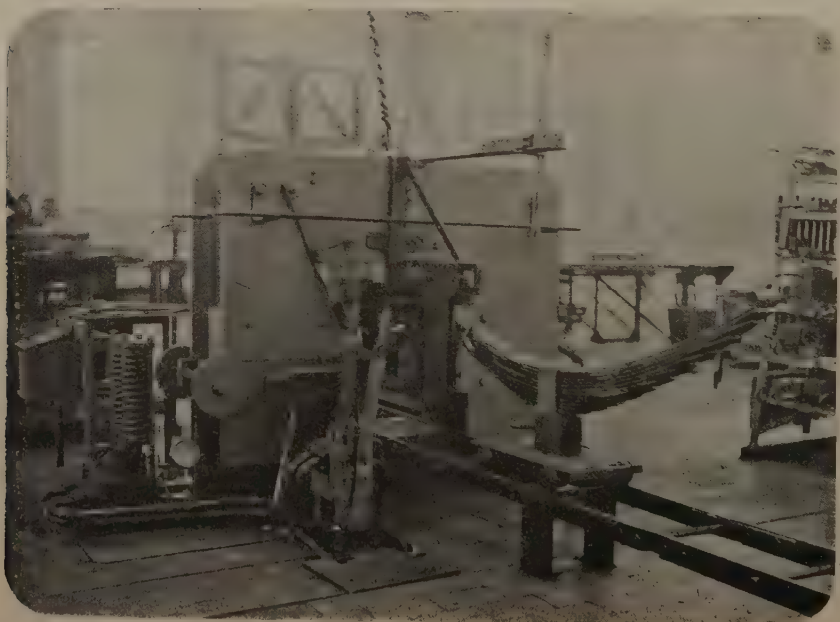


Fig. 9.

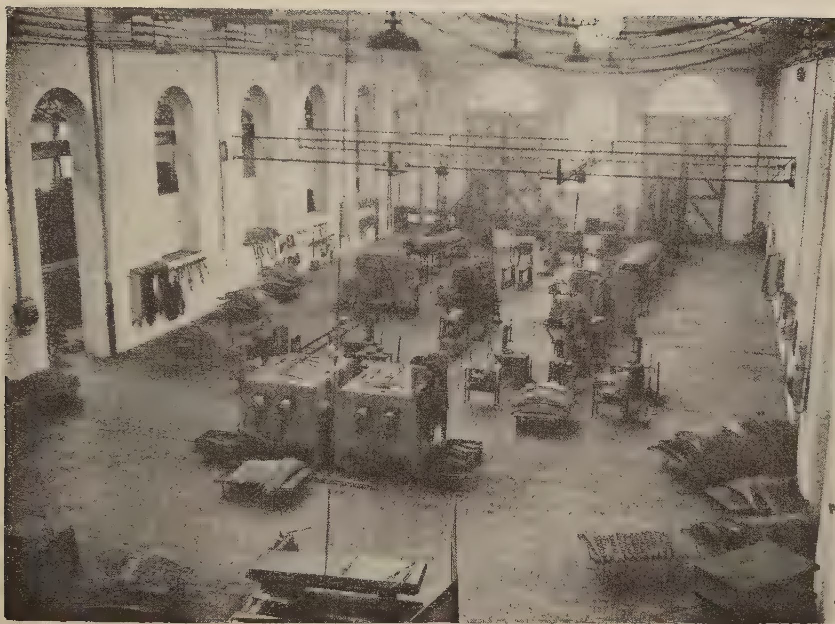


Fig. 10.

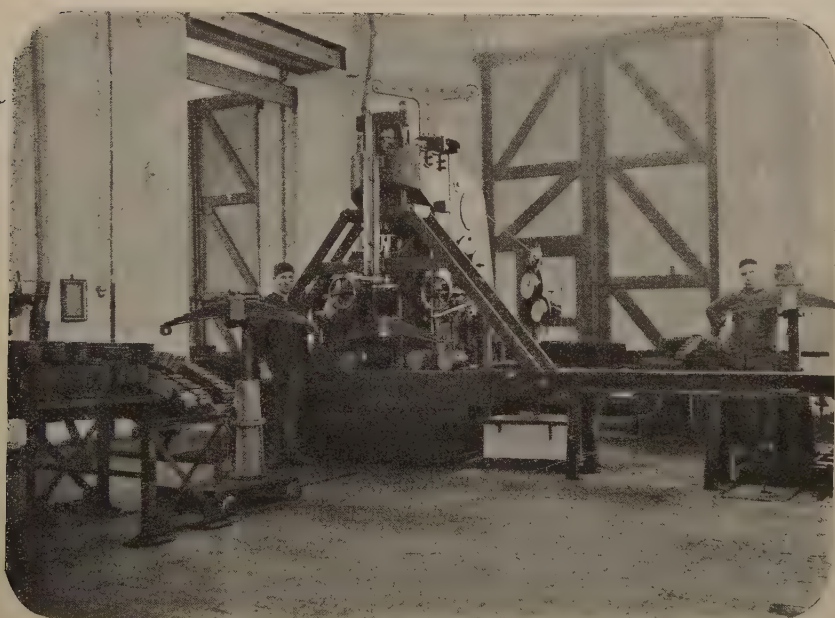


Fig. 11.

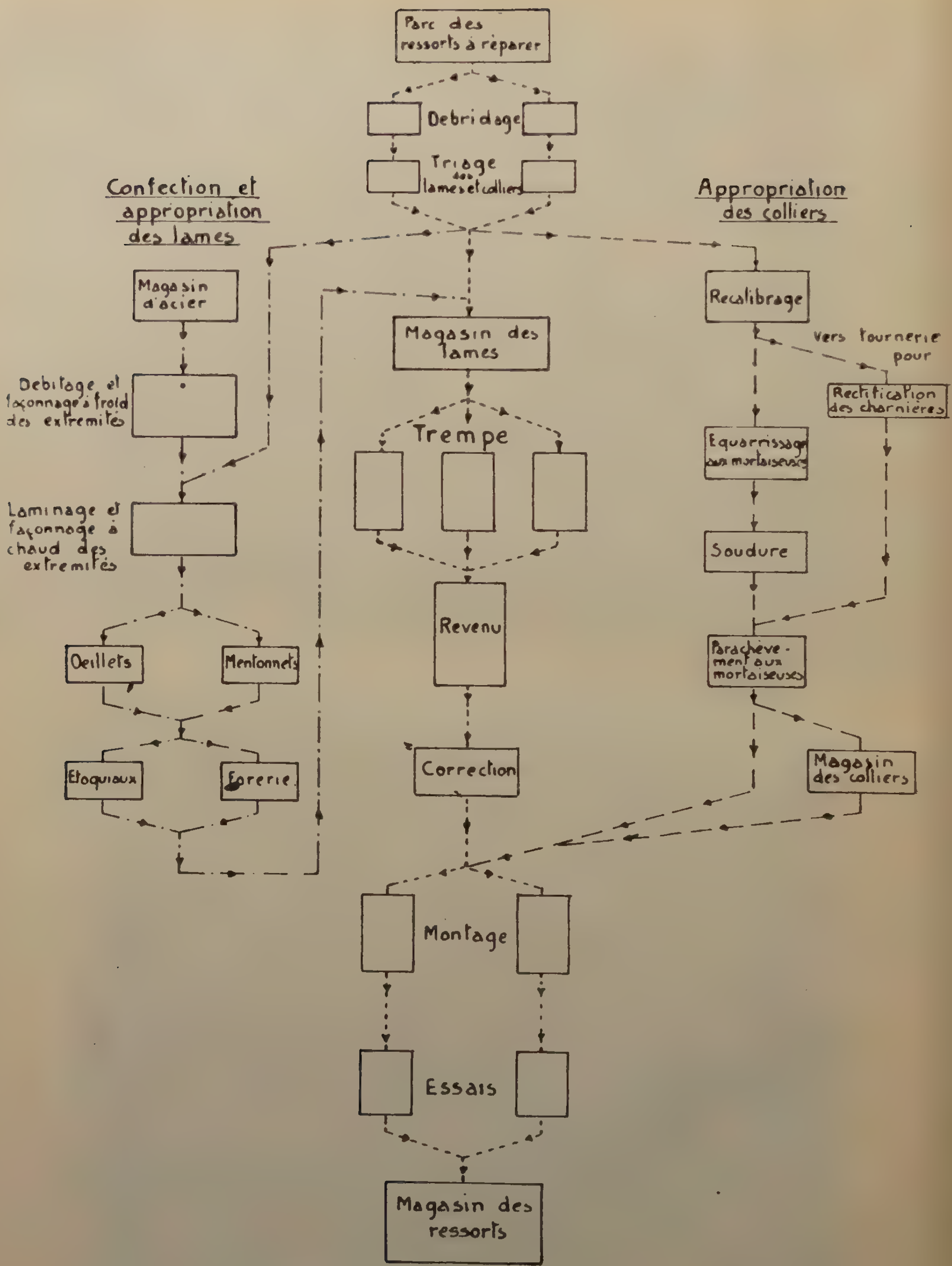


Fig. 12. — Organisation of the work.

Explanation of French terms in figure 12 (left to right) :

Confection et appropriation des lames = Manufacture and preparation of the spring plates. — Magasin d'acier = Steel store. — Débitage et façonnage à froid des extrémités = Cutting up and cold punching the ends. — Laminage et façonnage à chaud des extrémités = Rolling and working up the ends hot. — Œillets = Making eyes. — Mentonnets = Ridged plate ends. — Etoquiaux = Nibbing. — Forerie = Drilling machines. — Parc des ressorts à réparer = Stock of springs awaiting repair. — Débridage = Stripping off buckles. — Triage des lames et colliers = Sorting the plates and buckles. — Magasin des lames = Spring plates store. — Trempe = Hardening. — Revenu = Tempering. — Correction = Setting the plates. — Montage = Assembling. — Essais = Tests. — Magasin des ressorts = Finished spring stores. — Appropriation des colliers = Preparing the buckles. — Recalibrage = Regauging. — Vers tournerie pour rectification des charnières = To the turnery for truing link holes. — Equarrissages aux mortaiseuses = Squaring up on the slotting machines. — Soudure = Welding. — Parachèvement aux mortaiseuses = Finishing off at the slotting machines. — Magasin des colliers = Buckle stores.

rizontal and a vertical cylinder are able to press the buckles on 300 springs a day (fig. 9).

Before being returned to stores, repaired springs undergo the same tests as new springs : namely static and dynamic deflections, and verification of the deflection under load.

Two presses (31), one of 20 and the other of 30 tons, are used for these tests and take diagrams of the deflections in terms of the load applied.

Handling equipment.

An overhead crane of 1 000 kgr. (2 200 lb.) (32) covers the whole of the store yard D, in which the damaged springs are unloaded and sorted. It is used also to collect batches of the same type and load them on to a conveyor (33) with push-button control, by which they are taken inside the shop.

The springs are easily removed from the conveyer and put upon the machines for removing the buckles or the electric buckle-heating machine, as two 250 kgr. (550-lb.) electric blocks, moving in both directions, are provided.

The same equipment enables the springs to be removed from their truck after the buckles are pressed on and placed on the rollers (34) feeding them down to the testing machines (fig. 10).

A pneumatic revolving and rolling lift (30) specially designed for the purpose feeds the springs onto these presses (fig. 11).

Another of these lifts links up the testing presses and the mechanical conveyor (35) which conveys springs which have passed the tests and been painted, to the stores.

The stores occupy the end of the preparation hall, the whole of which is served by a two-ton electric travelling crane used to sort out the repaired springs and to load them up for dispatch (a standard-gauge line runs into this hall). The crane is also used to unload new spring bars, and in connection with repairs to the machine tools.

The complete springs are handled by the above equipment so that no manual handling is necessary.

The individual plates pass automatically through the furnaces (hardening and tempering) as described above.

Inclined conveyors take the springs as they come out of the furnaces to the hardening plant so as to reduce the attendant's manual work.

The whole of the shop has been properly paved so that motor trucks with elevating platforms and containers can handle all materials about the shop.

No buckles, plates, nor springs are allowed to lie about the floor, this rule being rigorously enforced.

Organisation of the work.

Figure 12 shows the logical order of the above operations. In a way, the belt system has been introduced, with subsidiary belts in the secondary shops for preparing the plates and buckles.

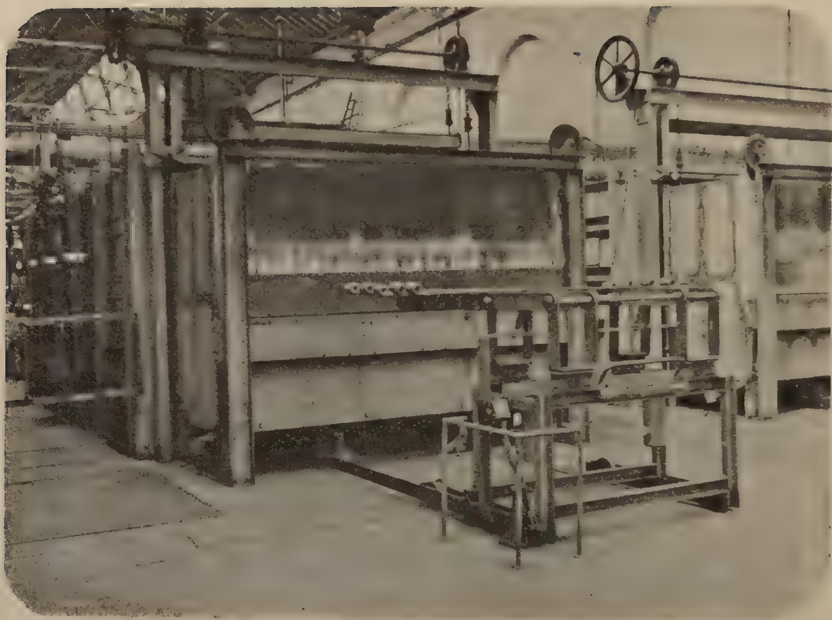


Fig. 13.

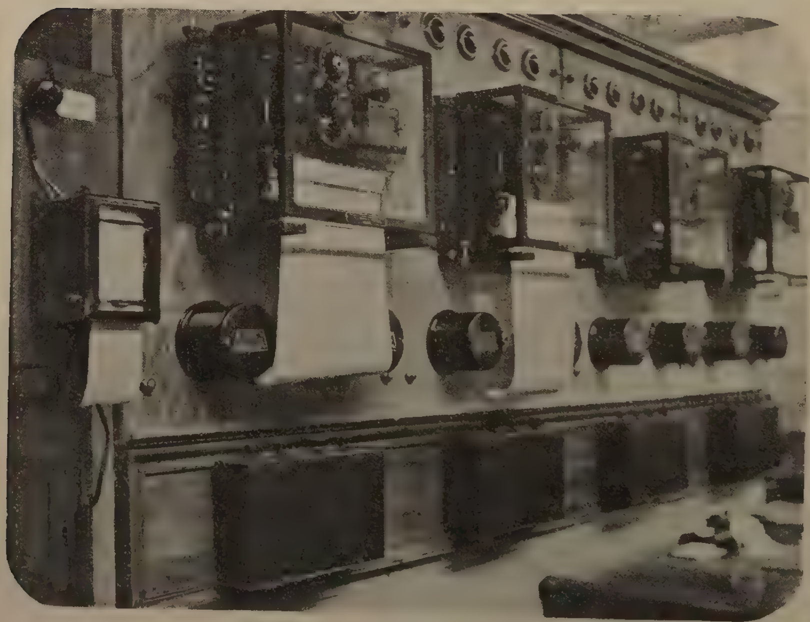


Fig. 14.

Other principles, now considered essential in shop management, have been applied in this case, too : namely mass production, work planning, instruction cards, tolerances, gauges, mechanical time keeping, interesting the staff in the production, automatic checking, statistics, etc...

Checks.

The object, in this specialised shop, has been to replace confidence in the often empirical experience of specialists by scientific manufacturing control.

The investigations into the best heat treatment were made at the Company's central laboratory.

Nothing has been neglected to carry it out in practice with accuracy.

The precautions taken to prevent the danger of an oxidising atmosphere in the continuous furnaces (fig. 13) are the following : a number of plates are put in an outer chamber of the furnace, the doors of which work automatically in conjunction with the charger, the discharge side of the furnace has double moveable flaps, the protection of the outgoing conveyor is covered in, extending as it were the tunnel, and the amount of air required for combustion is automatically regulated.

Automatic regulation. — The temperature of each of the heat-treatment furnaces is not only measured and recorded by potentiometers connected to pyrometers (chromel-alumel couple) in the laboratory, but the same apparatus automatically controls the electrically-operated valves in the gas mains (fig. 14).

It is essential that the desired temperatures be attained, but not exceeded; they must be kept constant in spite of variations in the load.

Temperature of the plates. — To keep constant the time between a plate leaving the hardening furnace and being immersed, the bending plant form is controlled by the plate itself as it passes the flaps of the furnace door.

The temperature of the plates is measured by exposing them for a few seconds in front of a pyrometer. This temperature is also recorded.

Temperature of the bath. — The hardening conditions can vary if the bath is not maintained at the correct temperature. A thermometer in the bath is connected to a recorder so that the working of a thermostat can be checked.

These precautions taken to obtain a perfect heat treatment are followed by a systematical examination of the results obtained.

The hardness of a certain number of plates of each of the series treated is measured by a direct reading machine using a Brinell ball or a Rockwell diamond (25).

The appliance is electrically-controlled by push button and is fitted with a counter to record the number of operations.

A Hilmer grinder (24) is used to remove the scale before making the tests.

The laboratory-office in the centre of the shop contains the whole of the pyrometer equipment (26).

Its equipment also includes a metallographic bench with apparatus for taking photo-micrographs.

In order to control the consumption of gas all the furnaces are being fitted with individual totalising recorders.

Results.

The whole of these special precautions to get accurate heat-treatment of the spring plates may appear unnecessary at first sight. This delicate operation how-

ever, requires that constant care which is only possible with automatically controlled equipment.

The results obtained wholly confirm this; the proportion of springs rejected during tests in spite of the severity thereof, is small. The life of these springs in service promises to be particularly long.

This means a notable reduction in maintenance costs, which is to be added to the direct saving in staff effected. The staff in this shop is less than half that previously employed in the old spring shops of this railway.

The cost of the Cuesmes spring shop will therefore be paid off in a few years.

621.131.1 & 656.221]

Traction diagrams based on the ratio of the power to the weight hauled,

by Dr. Ing. JAN BILEK, Prague.

A. — Foreword.

The use of internal combustion engines on railcars has given rise of late years to a new type of electric traction, the principal feature of which is that it maintains the power of the heat engine, and therefore practically the power at the wheel tread, constant over a wide range of speeds. As furthermore the work required from these vehicles varies much less than with locomotives, the ratio of the power at the tread to the weight of the train, which will be represented by $N_{/t}$ in this article, has now a definite meaning and is used frequently even in purely electric traction. As we will show later on, when the ratio $N_{/t}$ is introduced into traction calculations, simple diagrams can be drawn from which we can ascertain for all vehicles the values required in the calculations, such as the speed, the acceleration, the gradient, the power and the weight hauled. So that the utility of the diagrams may be properly understood, it should be noted that, as in the resistance formulæ used herein, we are not dealing with exact values, but simply with averages, all that is needed moreover in traction calculations.

B. — General diagram for the equation $\alpha + \beta v^2$.

The most widely used of the usual train resistance formulæ are of the general form

$$P_{o/t} = \alpha + \beta v^2 \qquad (1)$$

The formulæ of Clark, Frank, and Strahl are examples. A formula of the same kind is used on the Swiss Federal Railways.

When extended to take gradients into account, equation (1) becomes :

$$P_{/t} = \alpha + \beta v^2 + s \qquad (1a)$$

If we introduce the notion of power we get :

$$75 \times 3.6\, N_{/t} = 270\, N_{/t} = \alpha v + \beta v^3 + s v \quad (2)$$

Notations used :

$P_{o/t}$ = tractive effort in kgr. per metric ton hauled, required to overcome the rolling resistance and air resistance;

$P_{/t}$ = tractive effort in kgr. per metric ton hauled, required to overcome all resistances opposing the motion of the train;

$N_{/t}$ = horse-power per metric ton hauled, at the wheel tread. (1 H.P. = 736 watts);

v = speed in kilometres per hour;

s = rising of falling gradient in millimetres per metre;

α, β = constants in the resistance formulæ.

The value of s as calculated by means of (2) represents the rising or falling

gradient on which the speed is uniform i.e. without acceleration of retardation. We then get :

$$s = \frac{270\ N_{/t}}{v} - \alpha - \beta\, v^2$$

$$s + \alpha\ \frac{270\ N_{/t}}{v} - \beta\, v^2$$

$$\frac{s+\alpha}{270\ N_{/t}} = \frac{1 - \frac{\beta}{270\ N_{/t}} \times v^3}{v}$$

$$\frac{s+\alpha}{270\ N_{/t} \sqrt[3]{\frac{\beta}{270\ N_{/t}}}} = \frac{1 - \frac{\beta}{270\ N_{/t}} \times v^3}{\sqrt[3]{\frac{\beta}{270\ N_{/t}}} \times v}$$

$$\frac{s+\alpha}{\sqrt[3]{270^2 \cdot \beta \cdot N_{/t}^2}} = \frac{1 - \left(\sqrt[3]{\frac{\beta}{270\ N_{/t}}}\ v\right)^3}{\sqrt[3]{\frac{\beta}{270\ N_{/t}}} \cdot v}$$

If the following auxiliary values of x and y be used :

$$x = \sqrt[3]{\frac{\beta}{270\ N_{/t}}} \times v \qquad y = \frac{s+\alpha}{\sqrt[3]{270^2\, \beta\, N_{/t}^2}}$$

the simple equation

$$y = \frac{1 - x^3}{x} = \frac{1}{x} - x^2 \qquad (3)$$

is obtained.

The values $N_{/t}$ and β then lie within the limits of the values s and v. The value α is added to s. Figure 1 shows the curve corresponding to equation (3). To make the diagram more easily applicable, the usual values of the different constants are given in table 1.

The auxiliary values can be written :

$$x = \frac{v}{\gamma N_{/t}^{\frac{1}{3}}} \qquad y = \frac{s+\alpha}{\lambda N_{/t}^{\frac{2}{3}}}$$

with

$$\gamma = \sqrt[3]{\frac{\beta}{270}} \qquad \lambda = \sqrt[3]{270^2\, \beta}\ .$$

Table 1 gives the usual values of β.

TABLE I. — **For the constants γ and λ of the general diagram.**

β	γ	$\frac{1}{\gamma}$	λ	$\frac{1}{\lambda}$
0.00025	104.0	0.0096	2.63	0.380
0.00030	96.6	0.0104	2.80	0.357
0.00035	91.6	0.0109	2.94	0.340
0.00040	87.7	0.0114	3.08	0.325
0.00045	84.3	0.0119	3.20	0.313
0.00050	81.2	0.0123	3.32	0.301
0.00060	76.1	0.0131	3.52	0.284
0.00070	72.8	0.0137	3.71	0.270
0.00080	69.6	0.0144	3.88	0.258
0.00090	66.3	0.0149	4.03	0.248
0.00100	64.6	0.0155	4.18	0.239

The curve shown in figure 1 is known as a *trident*. It passes through a minimum value for $x_0 = 0.794$ and $y_0 = -1.885$ and shows a bend when $x_{00} = 1$ and $y_{00} = 0$. The right hand branch of the curve applies to positive powers

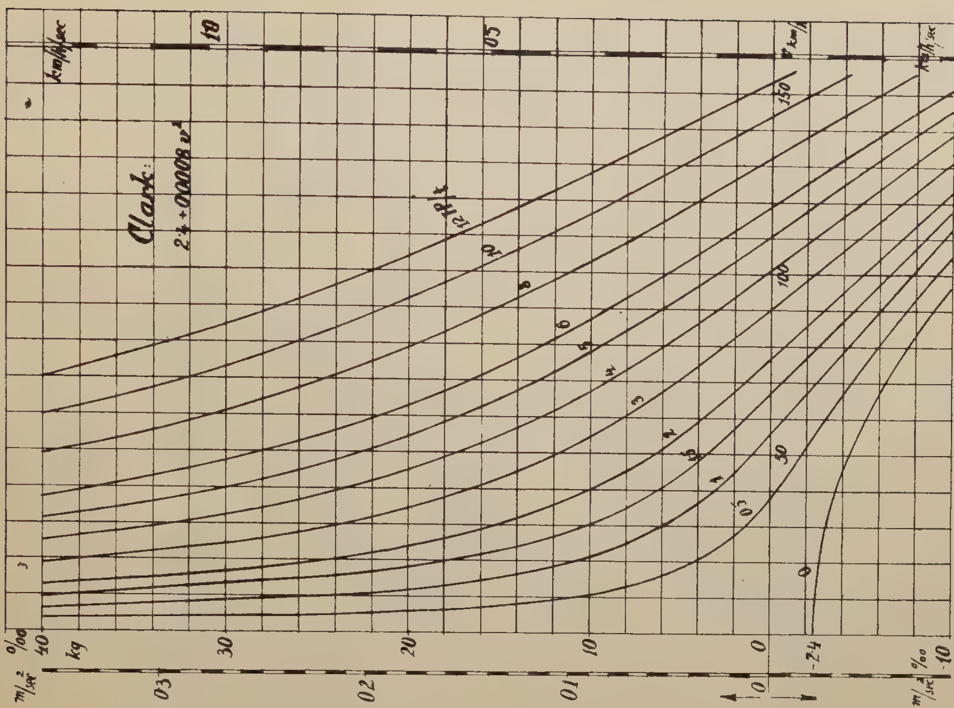

Clark:
2,4 + 0,00008 v²
km/h
m/sec
kg
‰
m/sec²
150
100
50
-2,4

Fig. 2.

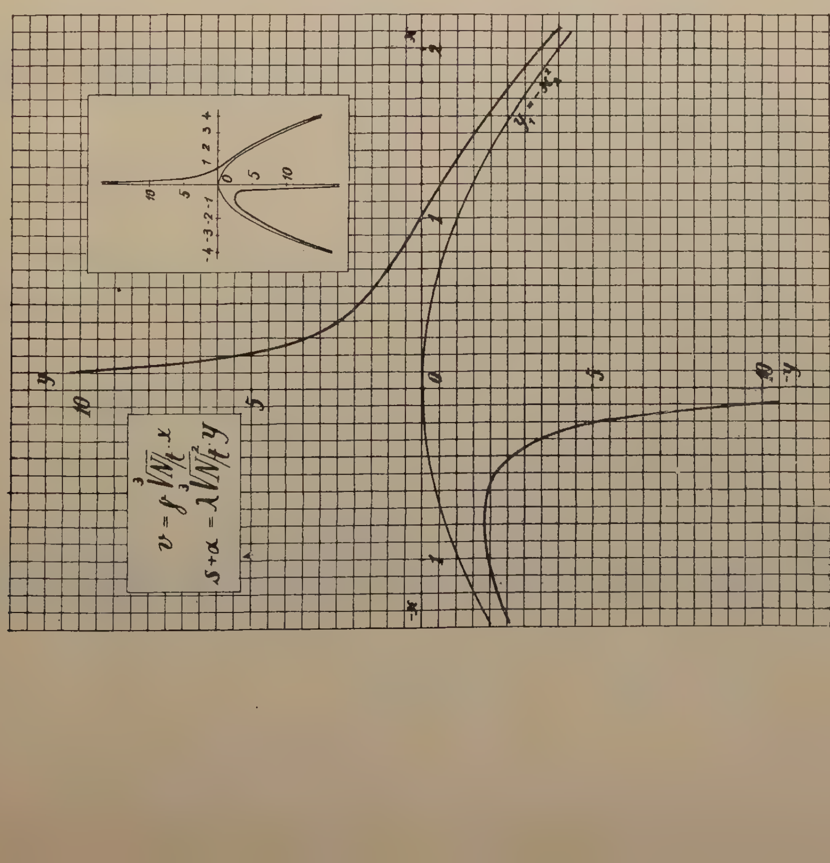

v = f ∛(N/t) · x
s + α = λ ∛(N²/t) · y

Fig. 1.

and the left hand to negative powers or regeneration.

The parabola also traced on figure 1 :

$$y_1 = -x_1^2$$

shows the tractive ratios when $N_{/t} = 0$.

In this case equation (2) becomes :

$$s + \alpha = -\beta v^2.$$

$$y_1 = \frac{s+\alpha}{\beta};\; x_1 = v.$$

This parabola is at the same time an asymptote to the curve of equation (3).

Examples showing the method of using diagram 1.

Using the Swiss Federal Railways' train resistance formulæ :

for passenger trains

$$P_{o/t} = 2.5 + 0.0003\, v^3,$$

for goods trains

$$P_{o/t} = 3 + 0.0005\, v^2,$$

we will calculate the speeds : *a*) of an express train of 480 metric tons, horse-power developed 1 600 (metric), on a rising gradient of 11 mm. per metre, and *b*) of a goods train of 1 000 metric tons, developing 2 400 H.P. (metric).

a) $N_{/t} = \frac{1\,600}{480} = 3.33$ H.P./t, $N_{/t}^{\frac{1}{3}} = 1.49$, $N_{/t}^{\frac{2}{3}} = 2.23$, $\alpha = 2.5$, $\beta = 0.0003$, $\gamma = 96.6$, $\lambda = 2.80$ (see table 1).

$$y = \frac{11 + 2.5}{2.8 \times 2.33} = 2.16.$$

According to diagram 1 when $y = 2.16$, $x = 0.425$,

$v = 96.6 \times 1.49 \times 0.425 = 61.2$ km. per hour.

b) $N_{/t} = \frac{2\,400}{1\,000} = 2.4$ H.P./t, $N_{/t}^{\frac{1}{3}} = 1.34$, $N_{/t}^{\frac{2}{3}} = 1{,}78$, $\alpha = 3$, $\beta = 0.0005$, $\gamma = 81.2$, λ 3.32 (see table 1).

$$y = \frac{11 + 3}{3.32 \times 1.34} = 3.15,\quad x = 0.29,$$

$v = 81.2 \times 1.78 \times 0.29 = 42$ km. per hour.

C. — Diagrams for Clark and Frank's resistance formulæ.

In the case of certain resistance formulæ in which the tractive effort per ton only varies with the speed, groups of curves can be drawn to show directly the tractive ratios. For these examples, we have chosen the well known formulæ of *Clark* and *Frank*, which are as follows :

Clark :

$$P_{o/t} = 2.4 + 0\;0008\, v^2.$$

Frank :

$$P_{o/t} = 2.5 + 0.0005\, v^2.$$

In Frank's formula, β is given an average value corresponding to that of passenger trains (see Sachs, *Vollbahn-lokomotiven*, p. 12).

Using the numerical data given above we get :

Clark :

$$270\, N_{/t} = 2.4\, v + 0.0008\, v^3 + s\, v$$

$$s = \frac{270}{v} N_{/t} - 2.4 - 0.0008\, v^2 \quad (5a)$$

Frank :

$$270\, N_{/t} = 2.5\, v + 0.0005\, v^3 + s\, v$$

$$s = \frac{270}{v} N_{/} - 2.5 - 0.0005\, v^2 \quad (5b)$$

There are in these two equations three unknowns, which can be represented by groups of curves. The diagrams, figure 2 are based on *Clark*'s formula and that

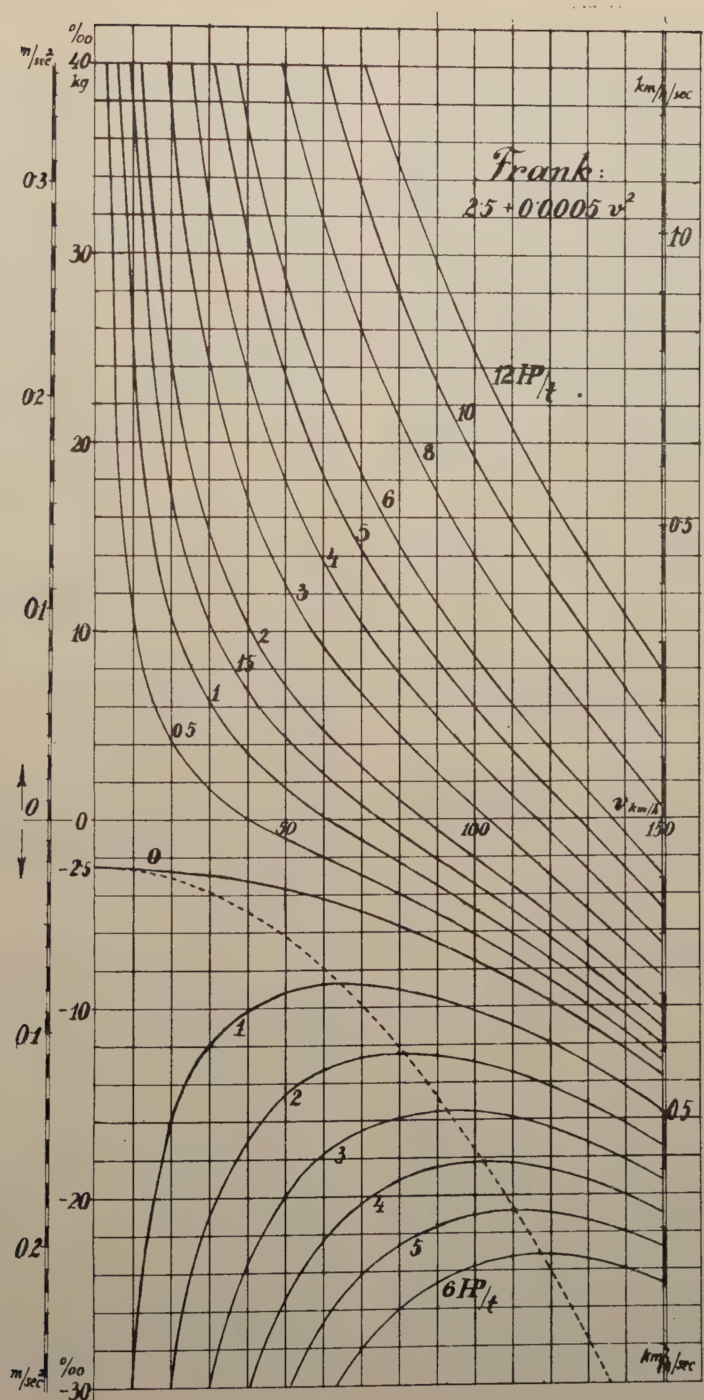


Fig. 3.

of figure 3 on *Frank*'s. The abscissæ represent speeds and the ordinates gradients. The power per ton is the parameter of the group of curves. The different curves are of the same characteristic as that of figure 1.

For *Frank*'s formula, curves corresponding to negative powers of 1 to 6 H.P. per ton have been drawn in figure 3. As we have pointed out already, they apply to regeneration or in a general way to braking. The maximum values of these curves lie on a parabola, the equation (6) of which is the derivative of (5*b*) :

$$s = -\frac{270}{v} N_{/t} - 2.5 - 0.0005\, v^2.$$

The derivative

$$\frac{ds}{dv} = 270\, N_{/t} \times v_m^{-2} - 0.0001\, v_m = 0.$$

$$v_m = 10 \sqrt[3]{270\, N_{/t}}$$

$$s_m = -\frac{270\, N_{/t}}{v_m} - 2.5 - 0.0005\, v_m^2,$$

$$N_{/t} = \frac{v_m^3}{270.10^3}$$

$$s_m = -2.5 - 0.0015\, v_m \qquad (6)$$

When $N_{/t} = 0$, equation 5*b* takes the simpler form

$$s_0 = -2.5 - 0.0005\, v_0^2 \qquad (7)$$

In both diagrams the ordinates represent the gradient in millimetres per metre corresponding to a tractive effort of the same number of kgr. per metric ton, so that the accelerating or retarding forces can be read off the diagram directly. These forces are proportional to the acceleration or retardation respectively so that these too can be ascertained from the diagrams. The relationships are given by the following calculation

$$P_u = 1.1\, a \frac{Q}{9.81} 1\,000 = 112\, a\, Q;$$

$$P_{u/t} = 112\, a \ (a \text{ in m./sec}^2);$$

$$P_{u/t} = 31\, a' \ (a' \text{ in km./h./sec}).$$

P_u, $P_{u/t}$ = the tractive effort available for accelerating the train,

1.1 represents the increase in value to allow for the revolving masses,

Q = weight hauled, a and a' = the accelerations,

$$a = \frac{P_{u/t}}{112} \text{ m./sec}^2$$

$$a' = \frac{P_{u/t}}{31} \text{ km./h./sec.}$$

The following examples show how the diagrams are used.

a) *Clark*'s formula :

What is the speed of a 100-ton train for 300 H.P. at the wheel tread on the level, or on a rising gradient of 10 mm. per metre, or on a down gradient of 5 mm. per metre?

$$N_{/t} = 3 \text{ H.P.}_{/t}.$$

The desired speeds are obtained from diagram 2, and are the points of intersection of the curve for 3 H.P./*t.* with the straight lines corresponding to 0.10 and — 5 mm. per metre, i.e. 90, 55 and 111 km.

What would be the acceleration of the same train on the level at 30 km. an hour and at 60 km. an hour? The ordinate for 30 km./h. cuts the curves for 3 H.P./*t.* at a point the height of which above the straight line of 0 mm. per metre shows on the acceleration scales 0.210 m./sec.² or 0.76 km./h./sec. For 60 km. per hour we find 0.074 m./

sec.², or 0.27 km./h./sec. On a gradient rising 10 mm. per m., the height of the point of intersection above the straight line for 10 % is marked and we get 0.120 m./sec.² or 0.43 km./h./sec. as the value shown in the scales of the accelerations. The fall in speed on the level on shutting down the engine at 90 km. an hour is given by the distance between the intersection of the ordinate for 90 km. an hour with the parabola for 0 H.P./t. and the straight line for 0 $^{0}/_{00}$. This gives 0.08 m./sec.² or 0.29 km./h./sec.

b) *Frank*'s formula.

What power can a 1 200-ton train regenerate on a down gradient of 15 mm. per m. without loss of its speed of 60 km. an hour? Diagram 3 shows for 15 $^{0}/_{00}$ and 60 km./h. a power between 2 and 3 H.P./t. the value obtained by interpolation being 2.4 H.P./t. Multiplied by the weight hauled, 1 200 tons, it shows a total power of 2 880 H.P. at the tread, provided the locomotive equipment is designed to allow it.

If the power regenerated were greater, 4 H.P./t. for example, the speed of the train would fall by 0.065 m./sec.² (0.23 km./h./sec.); at 30 km./h. the reduction of speed would be greater, namely 0.216 m./sec.² (0.78 km./h./sec.). If less power were regenerated, say 2 H.P./t. for example, the train would be accelerated 0.015 m./sec.² (0.054 km./h./sec.); this acceleration would increase until the speed were 80 km. an hour, when it would be 0.023 m./sec.² and would fall to zero at 130 km. an hour. The power per ton that can be regenerated on 10 mm. per m. down gradients, of which there are many on the main lines, can be obtained from the diagram. They are 1 H.P./t. at 40 km. an hour, 1.3 H.P./t. at 70 km. an hour, and 1 H.P./t. at 100 km. an hour, and therefore are not excessive.

D. — Mechanical method using a slide rule for traction problems.

The diagrams necessary for this purpose show the horse-power per ton and not the tractive effort in terms of the speed, as in the preceding case. In figure 4:

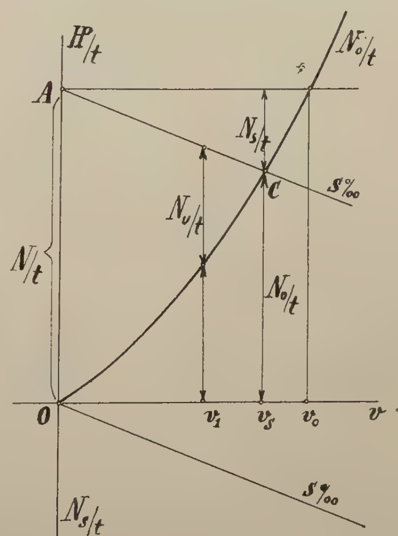


Fig. 4.

$N_{/t}$ = total power,

$N_{s/t}$ = power absorbed by the gradient s; this power increases directly as the speed v,

$N_{o/t}$ = power required to overcome the rolling and air resistances,

$N_{u/t}$ = power required for acceleration.

Figure 4 shows that the power taken by the gradient s (through the parallel to s $^{0}/_{00}$) can be deduced easily from the total power. At the speed v , the power $N_{/t}$ divides into $N_{s/t}$ and $N_{o/t}$ only. At a lower speed v, there is still the power $N_{u/t}$ available for acceleration. At the speed v_0, the total power is absorbed by the rolling and air resistances. The

train therefore can only run at this speed on the level.

The following equations are used in calculating diagrams 5 and 6 :

$$N_{o/t} = P_{o/t} \frac{v}{270}$$

$$N_{o/t} = \frac{2.4}{270} v + \frac{0.0008}{270} v^3$$

$$= 0.000889\, v + 0.00000296\, v^3,$$

according to *Clark*,

$$N_{o/t} = 0.000926\, v + 0.00000185\, v^3,$$

according to *Frank*.

These two formulæ are only used here as examples; other resistance formulæ converted into power can be used with diagram 5 if the resistance varies with the speed. In a way, this mechanical method is independent of the formula or rather can be used for any formula subject to the restriction just mentioned.

Table 2 gives the values $N_{o/t}$ for the above formulæ. In the case of rising gradients we get :

$$N_{s/t} = s \times v \frac{1}{3.6 \times 75} = \frac{s}{270} v.$$

This power, as we have pointed out already, increases directly with the speed for a given gradient. Diagram 6 shows it for a series of up or down gradients by a fan of radii. The scales are the same as for diagram 5, so that the two diagrams can be superimposed with the side lines coinciding. Let us suppose the two points O_1 and O_2 separated by a distance equal to the total power $N_{/t}$ (at the tread per ton). Figure 7 shows this case for 4 H.P/t. The intersection A of the curve Cl with the straight line representing the rising gradient of 10 mm. per metre gives the speed v_1 of the train in question. The diagram also enables us to ascertain the accelerative power namely $\overline{BC} = \overline{O_2D}$ for a lower speed v_2 on the same gradient.

The straight lines corresponding to the gradients are readily calculated by the last equation for the speed of 135 km. an hour.

$$N_{s/t} = \frac{s}{270} \times 135 = \frac{s}{2}, \text{ which}$$

gives 0.5 H.P./t. for each mm. per metre, i.e. for 10 mm. per metre 5 H.P/t.

A diagram for the accelerative power could be drawn up in the same way. The equations are :

$$a = \frac{P_{u/t}}{112} \text{ m./sec}^2 \; ; \; N_{u/t} = P_{u/t} \frac{v}{270}$$

$$= 0.415\, a \times v.$$

In this case too the power is directly proportional to the speed for a given

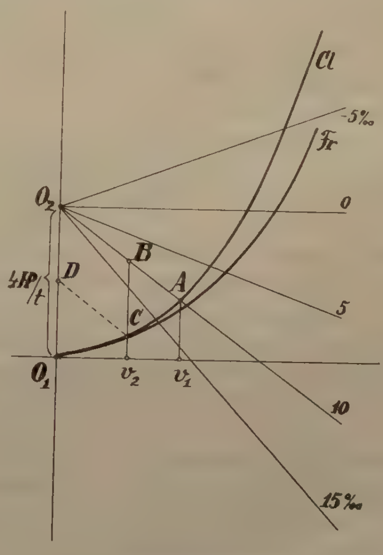


Fig. 7.

acceleration. So as to be able to use the same diagram for the gradients an allowance of 10 % must be made for

the revolving masses in the calculation of the forces and accelerative power. The formulæ then become :

$$P'_{u/t} = \frac{a}{9.81} \times 1{,}000, \quad a = \frac{P'_{u/t}}{102} \text{ m.sec}^2,$$

$$N'_{u/t} = P'_{u/t} \frac{v}{270} = \frac{0.01\ a\ v}{270}.$$

Within about 2 %, the same power is therefore required for each mm. per m. of gradient for an acceleration of 0.01 m./sec.$_2$ (1 cm./sec.$_2$) Consequently diagram 6, only including the corresponding designations, can be used. The acceleration or retardation obtained must, however, be reduced by about 10 % to allow for the effect of the revolving masses.

The two diagrams 5 and 6 can be brought together to form a slide rule as shown in figure 8.

A few examples of the use of diagrams 5 and 6.

Let us ascertain the speed, on a rising gradient of 15 mm. per metre, for a power of 5.5 H.P./*t*.

Diagram 6 is put over diagram 5 so that the sides coincide and the distances between the points O_1 and O_2 correspond to 5.5 H.P./*t*. The straight line for 15 °/$_{00}$ meets the *Clark* curve, if used, at 70 km. an hour, which is the speed to be found.

What is the power required for a speed of 120 km. an hour on a rising gradient of 5 mm. per m.?

Diagram 6 is moved along until the curve of diagram 5, in this case that of *Frank*, cuts at 120 km. an hour the straight line for 5 °/$_{00}$. The distance between the two points O_1 and O_2 then represents the power required, i.e. 6.5 H.P. per ton (metric).

What accelerations will 3 H.P./*t*. produce for 20, 40 and 60 km. an hour?

The distance between points O_1 and O_2

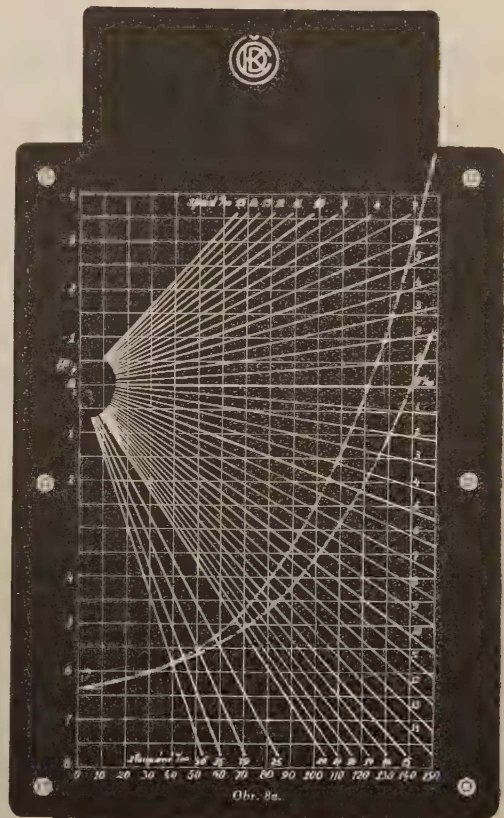


Fig. 8.

represents 3 H.P./*t*.; the points of intersection of the curves with the verticals representing the speeds are read off as follows :

20 km. per hour... about 0.4 less 10 % = 0.36 m./sec.^{2} for *Frank* and *Clark*;

40 km. per hour... about 0.17 less 10 % = 0.153 m./sec.^{2} for *Frank* and *Clark*;

60 km. per hour... about 0.08 less 10 % = 0.072 m./sec.^{2} for *Clark*,

and 0.09 less 10 % = 0.081 m./sec.^{2} for *Frank*.

The accelerations on the rising gradients are found in the same way : the

differences of the accelerations between the point of intersection and the straight line representing the gradients are used.

Conclusion.

The problems can be solved by nomographs but we think that for equations with 2 or 3 unknowns as those we are dealing with the nomographs do not simplify the calculation appreciably. Then too they are less clear as a rule than tables of curves.

The horse-power has been adopted as power unit as it is the unit usually used on the railways. There is no difficulty in converting the diagrams to kilowatts.

Appendix.

The following table of the values of equation (3) complete figure 1.

x	$\frac{1}{x} - x^2$	$\frac{1}{x} + x^2$	x	$\frac{1}{x} - x^2$	$\frac{1}{x} + x^2$
0	∞	∞	1	0	2.00
0.05	20.00	20.00	1.1	— 0.30	2.12
0.10	9.99	10.01	1.2	— 0.61	2.27
0.10	6.64	6.69	1.3	— 0.92	2.46
0.20	4.96	5.04	1.4	— 1.25	2.67
0.25	3.94	4.06	1.5	— 1.58	2.92
0.30	3.24	3.42	1.6	— 1.94	3.19
0.35	2.73	2.98	1.7	— 2.30	3.48
0.40	2.34	2.66	1.8	— 2.68	3.80
0.50	1.75	2.25	1.9	— 3.08	4.14
0.60	1.31	2.03	2.0	— 3.50	4.50
0.70	0.94	1.92	2.5	— 5.75	6.65
0.80	0.61	1.89	3.0	— 8.67	9.33
0.90	0.30	1.92	4.0	—15.75	16.25

The values required to prepare diagram 5 are given in the table hereafter.

	Clark's formula.			Frank's formula.			
Km./h.	$\frac{2\ 4\ v}{270}$	$\frac{0.0008\ v^3}{270}$	N_0/t H.P.	$\frac{2.5\ v}{270}$	$\frac{0.0005\ v^3}{270}$	N_0/t H.P.	Km./h.
10	0.089	0.003	0.092	0.093	0.002	0.095	10
20	0.178	0.024	0.202	0.185	0.013	0.198	20
30	0.266	0.080	0.346	0.278	0.050	0.328	30
40	0.356	0.189	0.545	0.371	0.116	0.487	40
50	0.445	0.370	0.815	0.463	0.236	0.699	50
60	0.533	0.640	1.173	0.555	0.400	0.955	60
70	0.622	1.015	1.637	0.649	0.634	1.283	70
80	0.711	1.516	2.227	0.741	0.948	1.689	80
90	0.800	2.160	2.960	0.834	1.35	2.184	90
100	0.889	2.860	3.749	0.927	1.85	2.777	100
110	0.978	3.950	4.928	1.018	2.46	3.478	110
120	1.066	5.125	6.191	1.100	3.20	4.300	120
130	1.155	6.510	7.665	1.202	3.89	5.092	130
140	1.244	8.15	9.394	1.295	5.08	6.375	140
150	1.332	10.00	11.332	1.388	6.25	7.638	150

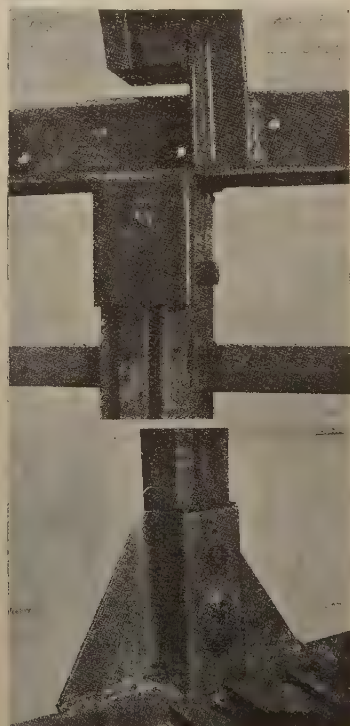
[628. 232 (.42)]

New first-class welded sleeping-car,

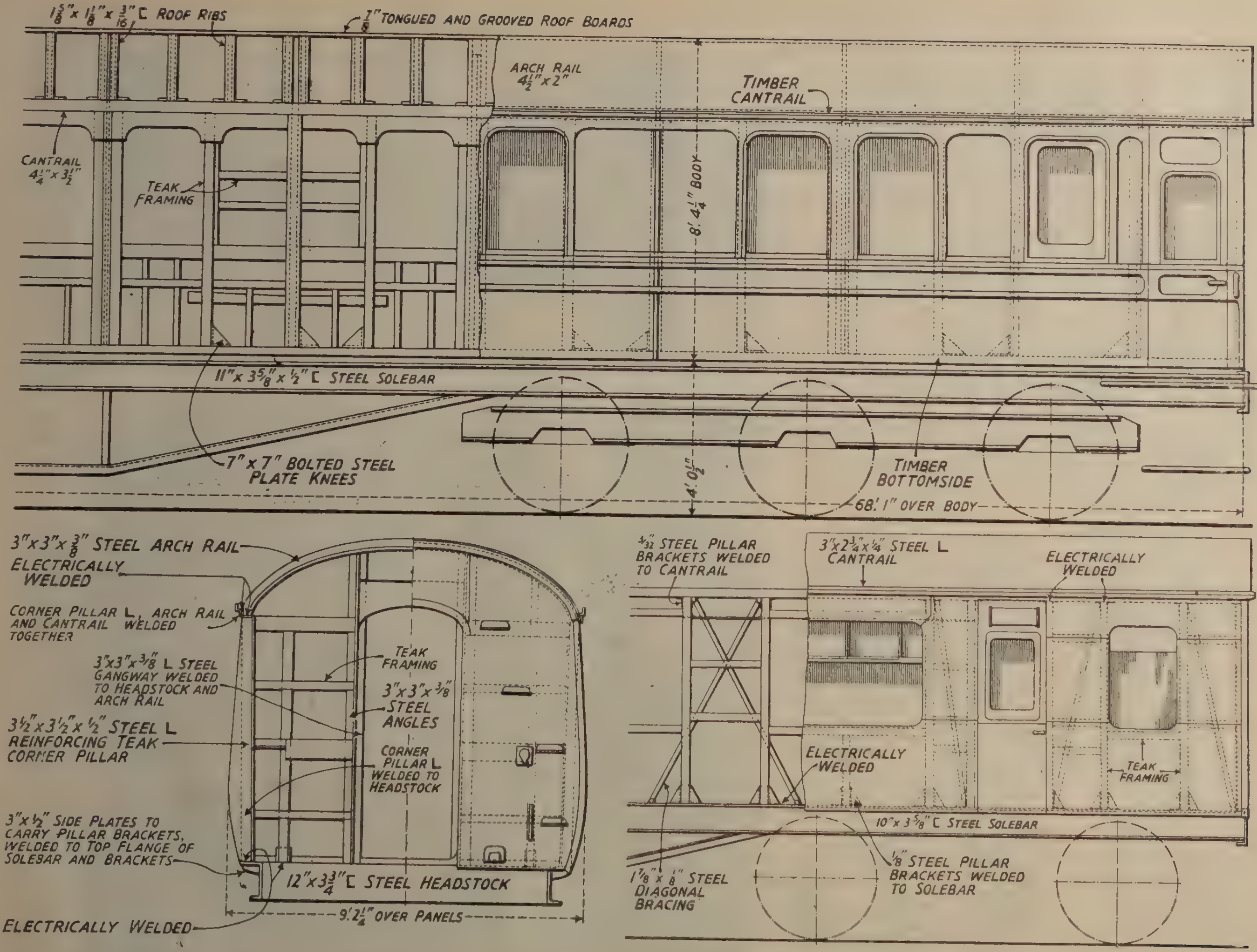
London Midland and Scottish Railway.

(The Railway Gazette.)

The first of an order for 26 first-class sleeping cars which are being built at the Wolverton Works of the London Midland & Scottish Railway to the designs of Mr. W. A. Stanier, Chief Mechanical Engineer, has recently been put into service. The construction of these vehicles marks a departure from standard practice in that electric arc welding has been used for building up the bogies, underframes and body framing, the body framing being constructed on a new principle. A further feature is that the vehicles are longer and wider than previous cars built by the company, the overall dimensions of the bodies being 69 ft. 1 in. long and 9 ft. 2 1/4 in. wide. Other dimensions are shown on the drawings reproduced. The extreme width of 9 ft. 2 1/4 in. has ne-

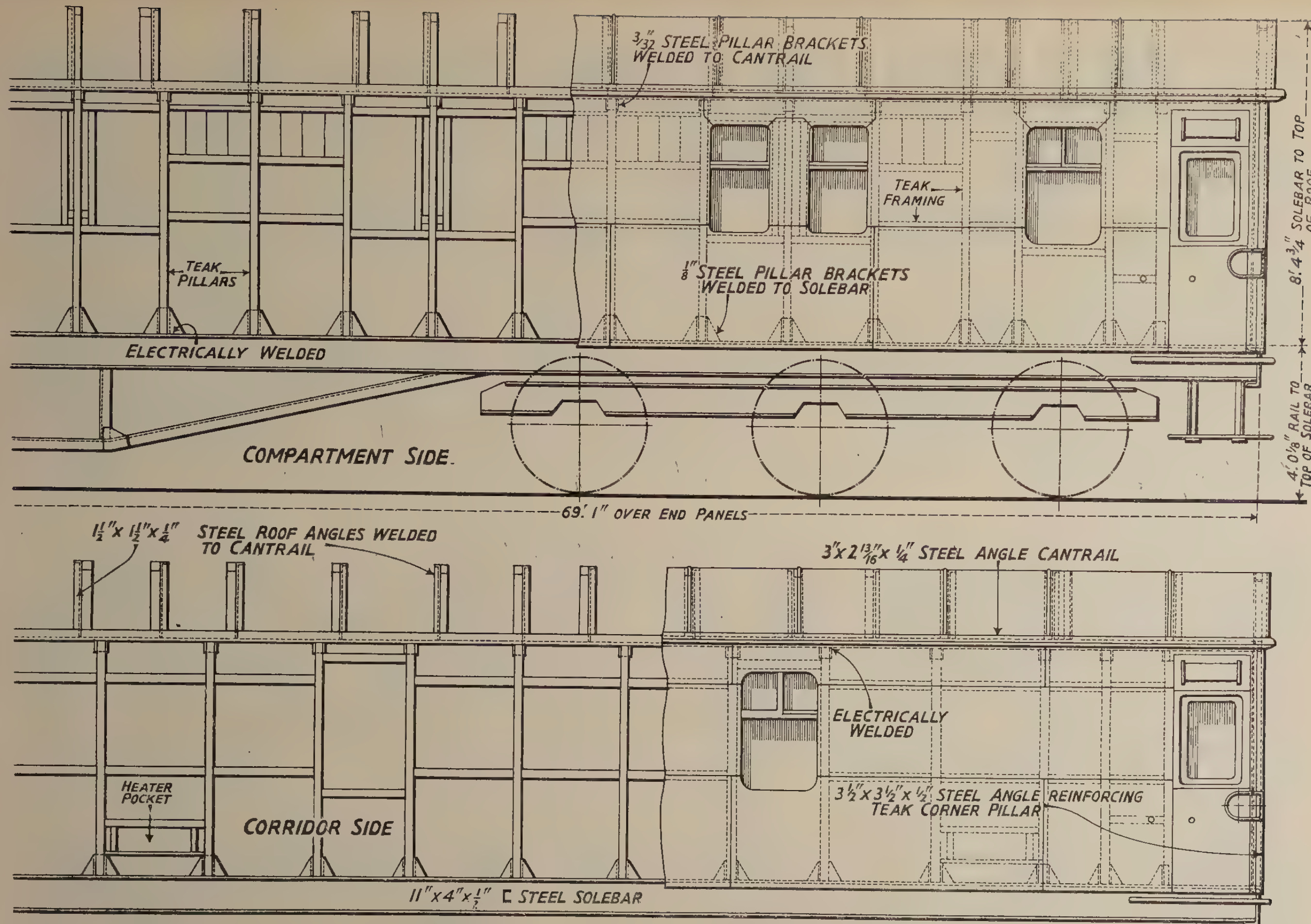


Welded connections of body framing. — Left and right (*above*) : Joints between cantrail, roof angles and pillar brackets. — Right (*below*) : Joint between pillar, pillar bracket and solebar.



(The Railway Gazette.)

Above : Constructional details of former standard sleeping car. Below (*left*) : Cross section of new sleeping car; (*right*) : constructional details of latest standard corridor stock.



(The Railway Gazette.)

Constructional details of body framing of new sleeping cars.

New standard carriage construction, London Midland & Scottish Railway.

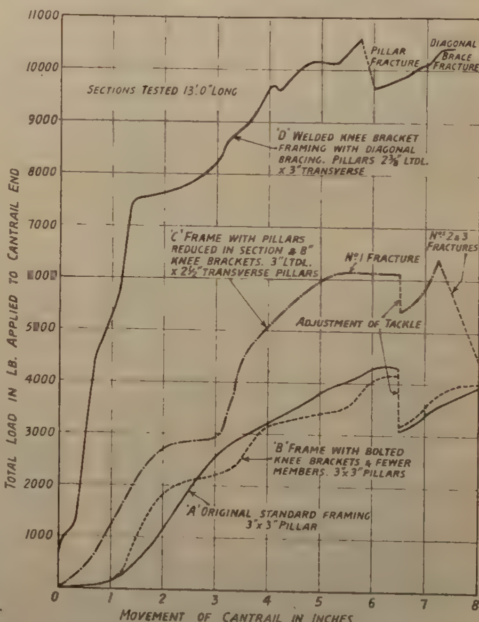
cessitated the recessing of the handles. In general appearance the cars follow the company's latest standard practice, having the windows flush with the exterior steel panelling.

Each car has 12 separate single-berth compartments, with a communicating door between each pair. There is a lavatory at one end of the car and an attendant's compartment at the other. The additional width has made it possible to use a slightly longer bed than usual, and the interiors of the compartments have been designed to present plain surfaces with chromium plated fittings, thus facilitating the maintenance of cleanliness, and producing a pleasing effect in trend with modern domestic design.

The welded bogies and underframes are based on standard methods of construction, so that standard brakework, springing and other equipment can be used. From the illustration of the bogie, the manner in which the usual rolled-steel sections are welded upon and riveting eliminated will be observed, the only riveting retained being on those parts which require fairly frequent removal, such as the brakework, axleguards and liners. The elimination of rivet holes has made it possible in some instances to use lighter sections. The underframe, also of steel sections, follows the general standard design except for the substitution of welding for riveting. Actually the welded joints have been designed to be stronger than riveting. This method of construction has made it possible to preserve a flush top, thus enabling the steel key sheeting which forms the floor base to be welded directly on to the underframe. The body pillars are brought right down to the level of the underframe and thus the use of bottom side members is dispensed with. The method of securing these pillars, which are of teak, has been the subject of numerous tests to arrive at the most satisfactory system. Each end of the pillar is bolted to a box bracket, pressed from 1/8 in. mild steel and welded directly to the underframe and the cantrail respectively, as shown in our illustrations. The cantrail is made up of lengths of angle section, joined by butt welds, and to it the roof angles and the arch rail angles are welded. The cantrails are drilled for riveting on the roof sheets, which are of 16 S.W.G. steel, and to take the gutter mouldings.

Preliminary tests.

Tests of different types of construction for the body sides were carried out and are illustrated on page 58. First a section with the body knees secured by coach screws was subjected to a shear



Results of tests on different types of body framing.

load (applied by a hydraulic ram at the end of the cantrail), and the resultant distortion and fractures are shown in the photographic reproduction, as well as in curve « A » in the above graph.

Another section, modified by the elimination of certain members and having body knees bolted through the pillars was then subjected to a similar test and gave the results also illustrated photographically and shown in curve « B » on the graph. The second test showed that even after the reduction in the number of members used, the structure was as strong as the first one. These tests demonstrated that mortised and tenoned timber joints, with body knees, were not the most satisfactory form of structure, while to obtain the maximum strength combined with lightness, timber should be used for compression and steel for tension members and fastenings. Upon these principles the design of box bracket adopted was evolved. Diagonal cross-bracing, of steel bar welded to the solebar and cantrail, has also been incorporated in the latest standard designs for vertibuled passenger stock for the L.M.S.R. Curve « D » on the graph clearly indicates the increased strength obtained by this type of construction. The cross section of the pillars is reduced by about 20 % when this diagonal bracing is used.

Independent tests made both transversely and longitudinally on pillars loaded as cantilevers indicated the comparative strengths of various sizes and methods of securing the pillars, and the graph reproduced below indicates the results, and shows that the new design with box brackets is about twice as strong as the previous standard.

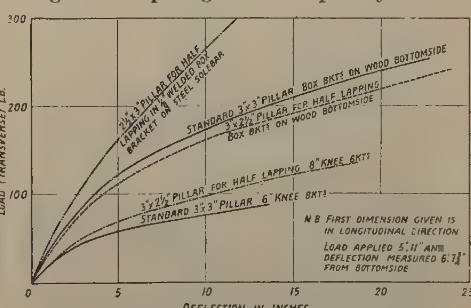
Owing to the wider body of the sleeping cars, increased « turnunder » was necessary, which made it impossible to incorporate cross bracing in these vehicles. Apart from this omission, however, which is to some extent balanced by the additional members necessary in providing the 12 compartments, the general features resulting from the tests have been applied throughout.

The coach ends are built of steel angles, welded together and to the headstocks, two of the angles forming very strong corner pillars. A previous source of weakness in timber ends has been the gangway back angle. This member has now been eliminated and the gangway sheet is fastened to two steel angles which form the door pillars for the end, and extend from the headstock to the arch rail.

The flooring is based on cork slabs shaped to fit the keyed grooves of the steel key sheeting on the underframe. The cork slabs are cemented in position with bitumastic solution, thus forming the surface to receive the felt, on which is laid linoleum, which in turn is covered by rugs in both corridor and compartments. The underside of the floor is sprayed with asbestos 3/8 in. thick to insulate the interior from track noises. The exterior panelling of the sides and ends is in 16 S.W.G. steel sheet, secured to the wood framing by screws.

Details of finish and equipment.

The compartments are finished in Rexine in four distinct colour schemes, yellow, green, blue, and beige, with a fade-out from floor to ceiling. The beds, which have a dummy head and foot of polished wood, are made up of a Vi-spring mattress on a spring frame, with hair mattress above. Each compartment has a sliding extractor ventilator light, and a sliding shutter with louvres, running on spring-loaded pulleys. The



Results of tests of pillars loaded as cantilevers.

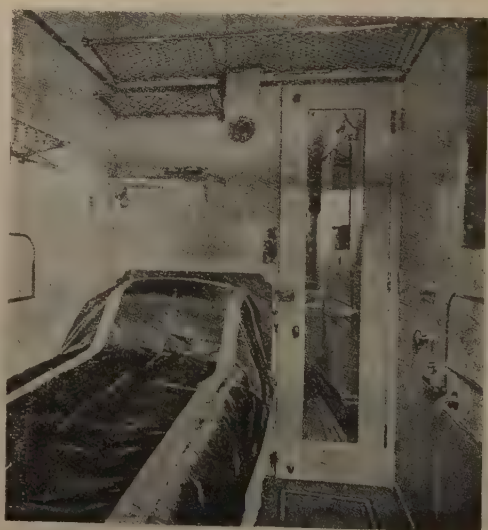
New first-class sleeping car, London Midland & Scottish Railway.

wash basin, which is of porcelain coloured to match the general colour scheme of the compartment, is housed in a cabinet at the foot of the bed, and has a hot and cold water supply. The corridor is finished in walnut and sycamore.

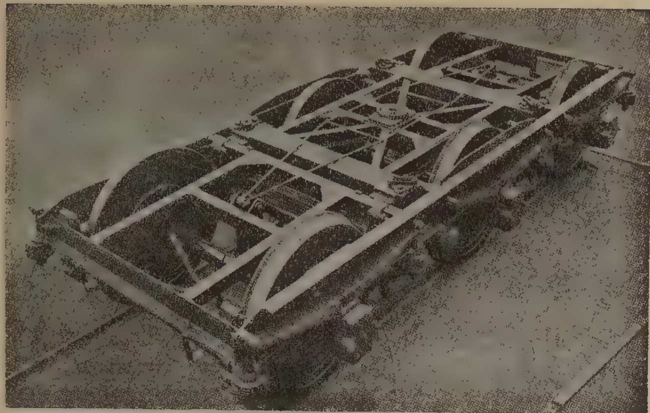
A combined heating and ventilating system of the induced air Themotank type is installed with Thermo-Reg control. Each berth compartment has a Punkah Louvre, fixed accessibly over the head of the bed, by means of which the passenger has individual control of the volume, direction, and temperature of the air entering the compartment. The ventilating equipment is housed above the ceiling of the vestibule adjoining the attendant's compartment, and consists of an electric motor, operating off the coach lighting equipment, direct-coupled to a fan on each side.

Air for the fans is drawn from outside the car, passing first through a metal-wool filter and then through a viscous oil filter, both of which are readily removable for cleaning. One fan delivers the air direct into the cold air duct and the other into a steam-operated air heater from which it passes into the hot air duct. These ducts are insulated and run through the length of the car above the corridor ceiling, with short ducts branching off to the regulators in the compartment.

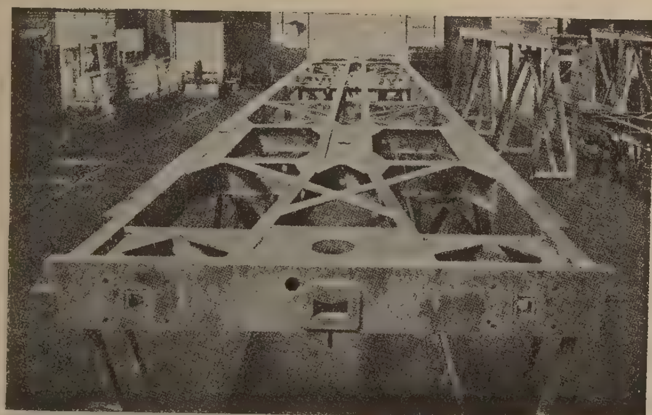
There is a louvred opening at the foot of each compartment door, thereby providing means for a ready circulation of the air. There is also a louvred opening in the vestibule ceiling beneath the ventilating unit which allows a proportion



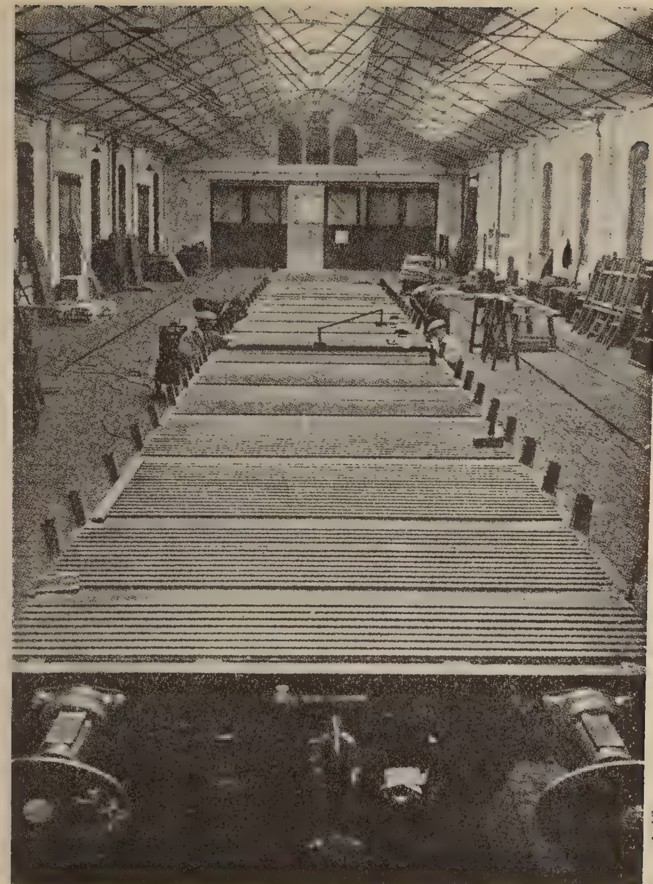
Interior of new first-class sleeping car, L. M. S. R.



Six-wheel bogie completely welded except parts requiring fairly frequent renewal.



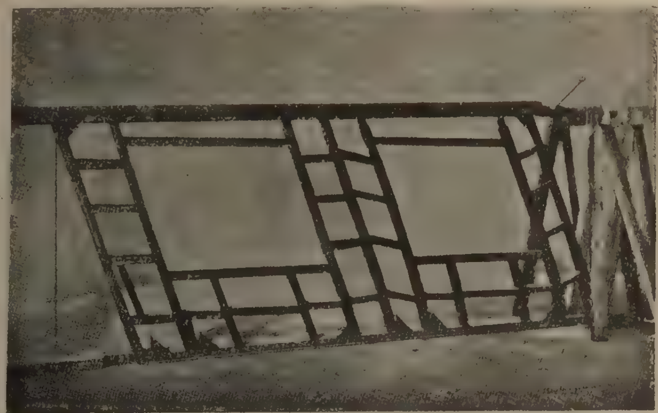
All-welded flush-top steel underframe. The welded joints are designed to be stronger than riveting.



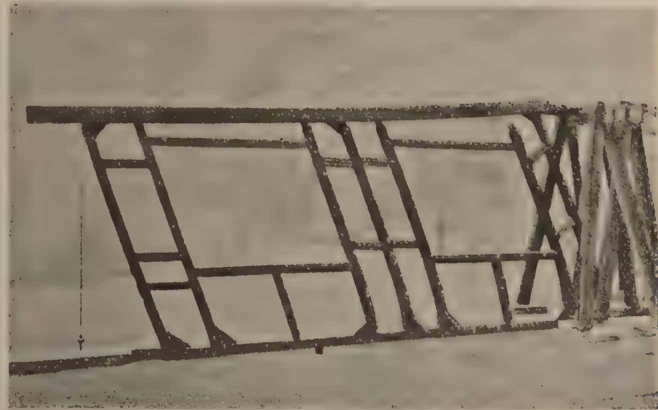
Welding pillar brackets to underframe to which the key-section floor base has already been welded.

Sections of former standard framing for 57-ft. corridor coach before testing. Body knees are secured by coachscrews.

Sections of modified design of framing with bolted body knees, before testing.



Section of former standard framing for 57-ft. corridor coach after testing. See also curve A of diagram on page 54.



Modified design of framing after testing. See also curve B of diagram on page 54.

New standard carriage construction, London Midland and Scottish Railway.

of the delivered air to be re-circulated, all of which passes again through a filter before being directed into the hot-air fan. The ceiling under the unit is in removable sections to give unimpeded access to the ventilating gear. The fans and air heater are controlled from the adjacent attendant's compartment, and there is provision for varying the fan speed in three stages. The capacity of the air heater is sufficient to maintain an adequate temperature in the berths, but to meet the wishes of passengers who desire another source of heat, each berth has also a steam tubular heater at floor level controlled by a wheel valve attached to the heater.

The L.M.S. standard Wolverton system of electric lighting which consists of a variable speed dynamo, a regulator and a battery of 12 lead-acid cells of 250 ampere-hours capacity is used. The cars are wired for R.C.H. through control, but the car lighting is not connected to this, being directly under the control of the attendant. All the lighting is by means of 15-watt, pearl lamps, those in the berths being housed in polished chromium finished reflectors. There is a lamp on the ceiling and one over the mirror on the side wall, in addition to a reading light in the corner over the head of the bed. The latter is controlled by a switch having « dim », « bright », and « off » positions. The switches for the roof light and reading light, together with a bell push to call the attendant, are housed behind a switch-plate on the door pillar beside the bed, while a switch under the mirror controls the lamp above. In the corridor, above each door, there is a drop-indicator for the bell circuit which is coupled through another indicator, and a bell in the attendant's compartment. The attendant's indicator is arranged to show whether the call has originated from the car or from the adjacent car on either side.

These new sleeping cars, it will be observed, are mounted on six-wheeled bogies, in order to ensure the smoothest possible riding.

[628. 143.2 (.73) & 625. 143.3 (.73)]

Rail fissures traced to shattered steel and heavy wheel loads [1],

by H. F. MOORE,

Research Professor of Engineering Materials, University of Illinois, Urbana, Ill.
(In charge of active test party. Rail investigation).

(*Engineering News-Record*).

For some twenty years the problem of rail failures from internal transverse fissures has been important with respect to both public safety and railway maintenance. Such failures are numerous and in the past have caused many bad train wrecks. Ever since the late James E. Howard first called attention to this type of failure in 1911, transverse fissures have been recognized to be a major railway problem, but in spite of extensive investigation their nature and treatment remained obscure.

Finally a systematic study in laboratory and field under the joint auspices of railways and rail manufacturers was initiated in 1931, and in four years of work this study has cleared up some of the basic questions involved. It has given strong evidence that transverse-fissure failures are closely related to the phenomenon of shatter-cracking in rails and can be controlled by careful thermal treatment after rolling; evidently the shatter-cracking is due to destructive stresses set up during the cooling of the rails on the mill hotbeds. High wheel loads and impact from flat wheels contribute greatly to the danger of fissure formation, it was also found. Improved methods of rail manufacture that are now available give promise of a marked reduction in the development of internal fissures in service.

(1) An abstract of Bulletin 376 of the American Railway Engineering Association.

Cooperative rail investigation.

The current rail investigation is under the joint auspices of the Rail Manufacturer's Technical Committee, the Association of American Railroads, and the Engineering Experiment Station of the University of Illinois. The headquarters of the investigation are at the materials testing laboratory of the University of Illinois, and the active test party comprises some eighteen testing engineers, metallurgists, test assistants and mechanicians under the direction of the writer. An advisory committee of eighteen members was appointed by the rail manufacturers' committee and the A. A. R., with F. W. Wood, of Baltimore, and Earl Stimson, chief engineer of maintenance of the Baltimore & Ohio Railroad, as joint chairmen.

The details of the study necessarily evolved during the progress of the investigations. In general, five lines of inquiry were included, though in addition there were many special tests and studies. These five are :

1. A laboratory study of the mechanism of formation of internal fissures in rails under repeated wheel loads.

2. Field studies of the range of magnitude of wheel loads occurring in service.

3. A critical study of acceptance tests for rails and a study of proposed non-destructive tests for rails.

4. Tests of rails made by special processes designed to prevent internal shatter-cracking during manufacture.

5. Service tests of test rails under traffic.

The last-named tests are now in progress. Their results may, after some years of service, modify the conclusions drawn from laboratory tests.

Stress and fatigue in rails.

Under traffic, damage to rails may be caused by either of two distinct systems of stress : (*a*) stress due to bending moment; or (*b*) a complex system of stress set up directly under a wheel load. The reports of the joint committee of stresses in railroad tracks of the A. R. E. A. and the A. S. C. E., of which Professor A. N. Talbot is chairman, furnish the necessary mathematical analysis for computing the stresses due to bending moments. (See reports of the joint committee for 1920, 1923, 1925 and 1929). In Bulletin 212 of the Engineering Experiment Station of the University of Illinois, H. R. Thomas and V. A. Hoersch have developed the Hertz analysis for stress in cylinders under radial compression so as to determine the stresses in the metal slightly below the surface of the head of the railroad rail under a wheel load, with special attention to the shearing stresses.

Using the formulas developed in the latter study, figure 1 shows the theoretical shearing stress in a rail head due to the direct action of a wheel load. It is to be noted that the steel immediately below the surface is stressed beyond its elastic range, and consequently the formulas do not hold for that region. However, test results indicate a fair agreement of actual with computed stress values at depths of 1/2 inch or more below the surface, where the nuclei of fissures are usually found.

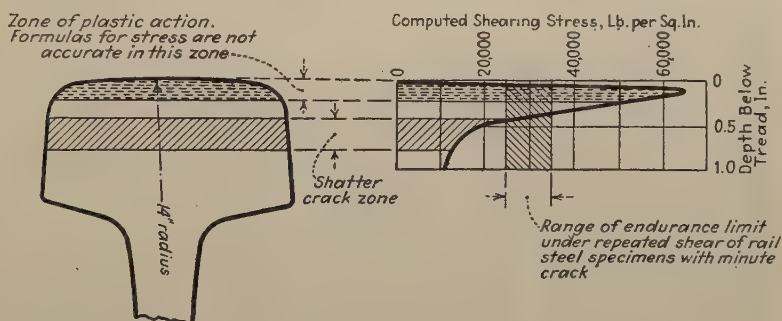


Fig. 1. — Wheel-loads set up high shearing stress a short distance below the bearing surface of the rail. (40 000-lb. load on 33-in. wheel; stresses computed by analysis developed by H. R. Thomas and V. A. Hoersch. In the upper zone the steel undergoes plastic deformation, and the computed results here are not accurate.)

During the past fifteen years the belief that an internal fissure in a rail is a gradually spreading fracture (in other words, a fatigue failure) has gained ground and may now be considered fully established. The investigations under discussion fully confirm the « fatigue » nature of internal-fissure fractures.

Probably the commonest cause of fatigue failures in structural and machine parts is localized high stress at « stress raisers », such as notches, small holes and cracks. In rail steel, as was shown by tests made in connection with the present investigation, a minute crack will reduce the strength of the metal to resist repeated stress by about one-half.

For many years the presence of internal cracks (shatter-cracks) in newly rolled rails has been revealed by etch test, and much discussion has taken place as to the cause of such cracks, their presence or, absence in rail steel before etching and their effect in starting spreading fissures (See « Deep etching of rails and forgings », by F. M. Waring and K. E. Hofammann, describing etch tests, *Proceedings*, American Society for Testing Materials, 1919, with extended discussion following). The present investigation included extensive work on the presence of such shatter-cracks in new rails and on the effect of these cracks on the strength of the rails.

In these tests on new rails the first step was to cut off a 6-inch test section, about 30 inches from the end of the rail, to slice the head into horizontal strips and to make an etch test. The rail was then tentatively classified as shatter-cracked or not shatter-cracked. The question as to whether shatter-cracks exist in newly rolled rails before etching, or whether they are the result of the etching process, is of only academic interest, because a condition such that a crack can be started by etching or by a slight change in localized stress is about as damaging as is the presence of an actual crack. However, by the use of high magnification, cracks were detected in some unetched slices of newly rolled test rail. The difference in appearance of sound and shatter-cracked rails after etching is shown by figure 2.

Tests in a rolling-load machine.

At the outset of the investigation 165 rails of 130 lb. per yd. and 130 rails of 110 lb. per yd. were furnished for test purposes. These rails came from five different mills and were made in the ordinary way—that is, cooled on hot-beds. The remaining rails in the heats from which these test rails were taken were put in service in railroad tracks at various test locations.

The laboratory study of the way in which internal fissures are formed was carried on by means of special rolling-load testing machines based on the same principle as a testing machine previously used by Prof. W. M. Wilson for tests of bascule bridge rollers. This machine applies cycles of definite and controllable wheel load and bending moment to a specimen length of a rail. Its construction is shown in the accompanying photograph, figure 3.

A short specimen of rail, *S*, is moved backward and forward under a wheel load. The load, which can be varied from zero to 80 000 lb., is applied through the lever *L* by means of a screwjack *J* and is measured by the compression of the spring *P*. The maximum bending moment is the product of the load on the wheel and the overhang *l* of the specimen when it is in its extreme left-hand position; the overhang may be varied by moving the block *B*. The stroke of the machine is 7 inches and the speed is 55 r.p.m. A revolution counter is attached to the crankshaft of the machine, and an automatic cutoff switch is operated by the dropping of the lever *L* when the specimen fails.

More than 200 rail specimens have been tested in the three rolling-load testing machines in use, many of them to 1 000 000 or more cycles of stress. Failures due to internal fissures have been developed in a considerable number (though by no means all) of the specimens cut from newly rolled test rails in which etch tests had shown shatter-cracks. It is to be noticed that by no means do *all* shatter-cracked rails develop fissures either in laboratory tests or in service in the track. No failures starting from internal fissures have been developed in laboratory tests of specimens from newly rolled rails free from shatter-cracking. Whenever such uncracked rails failed in the rolling-load tests, they failed by a fatigue

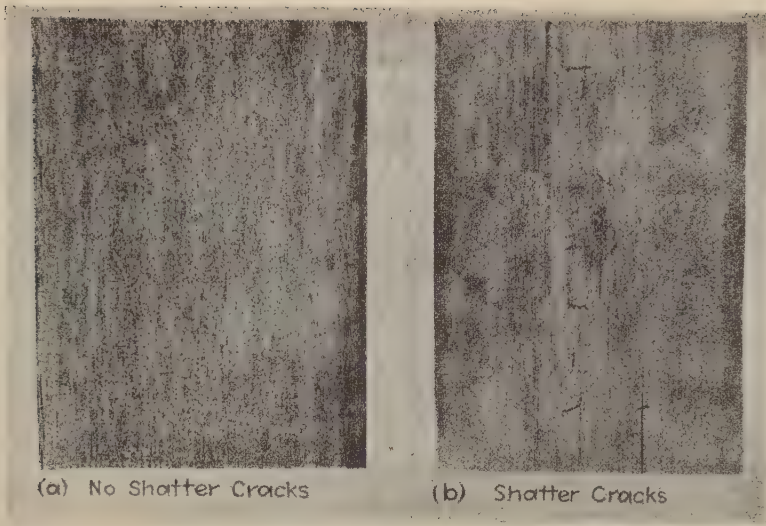


Fig. 2. — Sound and unsound rails as revealed by deep etching of a horizontal slice. Rail at right shows shatter-cracking.

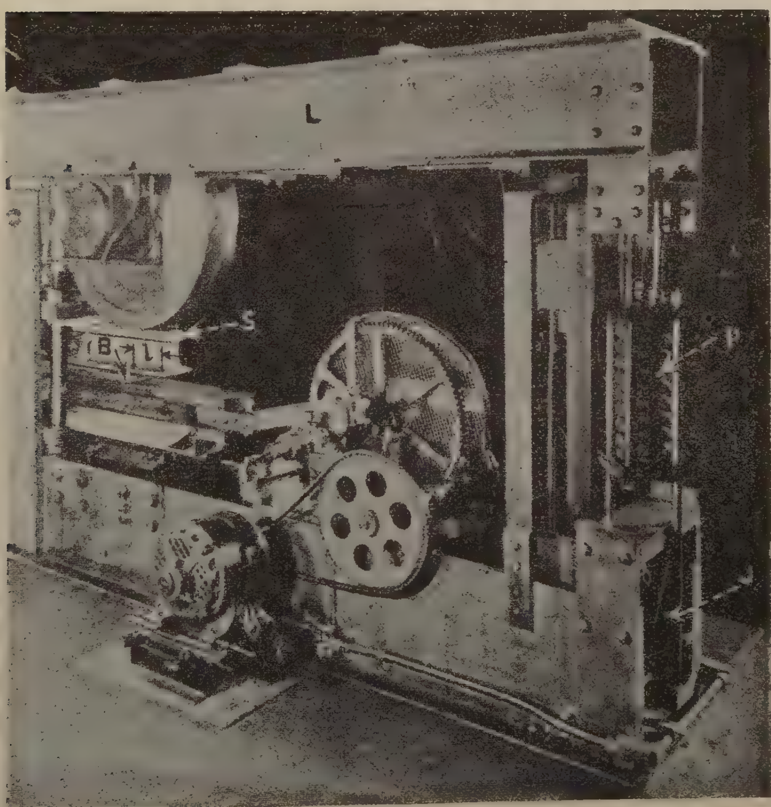


Fig. 3. — Artificial transverse fissures were produced by fatigue action in rolling-load testing machines of the kind here shown. The machine and method of operation are described on page 62.

crack that started at the surface of the rail; moreover they required higher wheel loads to cause fracture than did shatter-cracked rail specimens. The two types of spreading fracture are illustrated in figure 4.

Confirmatory evidence of the connection between shatter-cracking and transverse fissures was supplied by study of fractured rails received from service. About 77 % of such rails showed evidence of shatter-cracks in addition to the fissure that caused the fracture of the rail.

Internal fissures and stress under load.

In rolling-load tests of rail specimens, internal fissures have been developed at sections where bending moments were very small, but never at sections of heavy bending moment located outside the path of the wheel load. This is evidence that it is the stress due to the direct action of wheel load which *starts* spreading fissures, and a study of the different stresses indicates that the shear stress is most dangerous. A study of rails in which spreading fissures were produced shows, however, that the *direction* in which a fissure spreads is strongly affected by the relative size of wheel load and bending moment. High bending moment tends to cause fissures to spread as transverse fissures, while in rails with low bending moment and high wheel load the fissures tended to spread in a horizontal plane. The direction of a shatter-crack also influences the direction of a spreading fissure.

The stresses directly under a wheel load are practically independent of the size of the rail, being confined to a very small volume of steel. The use of heavy rails would, then, seem to offer no direct relief from the danger of fissures. It may, however, offer some relief in two indirect ways :

(1) heavy rail may make smoother riding track and hence reduce the impact stresses set up in rails and wheels; and

(2) heavy rail reduces stress due to bending moment, and hence tends to cause any fissure to spread in a horizontal or a vertical-longitudinal plane rather than in a transverse plane.

How the failure of rails in the rolling-load tests is related to shear stress (as computed by the theoretical formulas) is set forth by the test plotting of figure 5. The fatigue limit of uncracked rail steel under shear varying from zero to maximum was found to range from 55 000 to 65 000 lb. per sq. inch. Fatigue tests of specimens of rail steel with a small crack showed a reduction of fatigue limit to about 50 % of that of uncracked steel. The fatigue limit of the steel in the center of the head of a shatter-cracked rail, then, might be expected to range from 27 000 to 32 000 lb. per sq.in. for shearing stress repeated but not reversed—the cycle of stress to which a rail is subjected under the direct action of passing wheel loads.

In figure 5 all test results are for newly rolled rails. It will be noted that all but one of the 24 specimens in which internal fissures developed were subjected to shearing stress within or above the fatigue range for shatter-cracked steel. In the case of those shatter-cracked specimens which failed by fatigue failure starting from the surface, all but six failed under theoretical shearing stress *below* this range, and at high bending stress. Of the 118 specimens that showed no shatter-cracks in the etch test and that failed by fatigue fracture starting from the surface, all but eleven failed at stresses below the fatigue limit for uncracked steel for repeated shearing tress, and all but seven failed at flexural stresses equal to or greater than the probable endurance limit for rail steel under repeated (but not reversed) flexure—about 80 000 lb. per sq. inch.

Thus, all the observed phenomena and

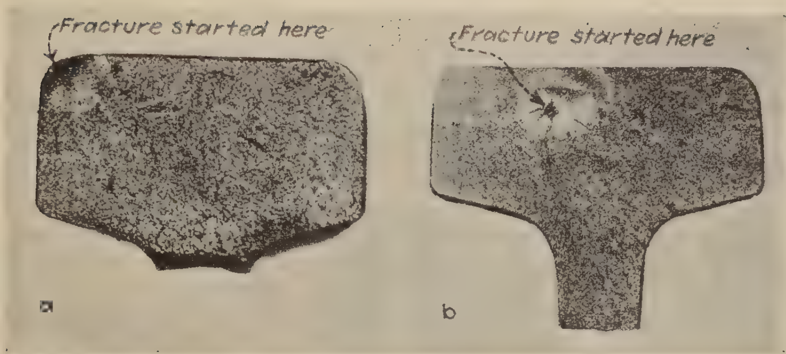
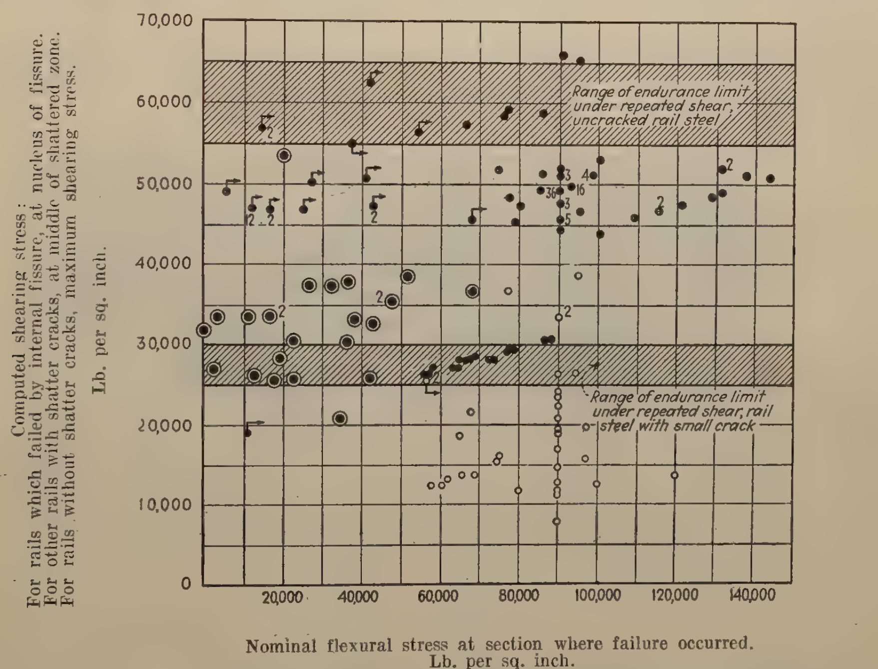


Fig. 4. — Fatigue failure occurred in typically different forms. Rails free from shatter-cracking failed by a fracture starting at the surface. Shatter-cracked rails formed internal transverse fissures at lower wheel-loads than the other rails carried.



- ● Fatigue failures (118 specimens) starting at surface. No shatter cracks shown in etch test.
- o Fatigue failures (30 specimens) starting at surface. Shatter cracks shown in etch test.
- ◉ Failures (24 specimens) starting at internal fissures. Shatter cracks shown in etch test.

|➛ Specimen did not fail during test ● (29 specimens).

Figures at plotted point indicate the number of specimens tested at that combination of shearing and bending stress.

Fig. 5. — Rolling-load test results established that rail fatigue was due to shearing stress directly under wheel load rather than bending stress, and that rails free from shatter-cracking had much higher endurance strength than shatter-cracked rails.

test measurements—theoretical shearing stress in the railhead directly under the wheel load, results of rolling-load tests, results of fatigue tests of specimens of rail steel, and results of fatigue tests of specimens containing a minute crack—combine to present a consistent picture of the mechanism of development of rail fracture as a spreading internal fissure. At the present time and subject to revision of belief by final results from the test rails in service, it is felt that this rails investigation has yielded fairly convincing evidence that internal fissures in rails usually originate at shatter-cracks that form in some rails during the process of manufacture.

Effective wheel-load measured.

The nominal load on any car-wheel is the dead weight which it carries. This latter is known with a fair degree of accuracy. Due to inertia forces set up by lack of balance of rotating parts, closing solid of springs, flat spots and out-of-roundness of wheels, and irregularities of track surface, the actual load under a moving wheel may differ widely from the nominal, being greater in some points along the track and less at others. Increase of wheel load, spoken of as the « dynamic augment », is of importance in considering strength of rail.

The method adopted for measuring wheel load (including dynamic augment) was an indirect one which did not involve altering track conditions. The elastic elongation along a short length of the lower flange of the rail was measured by means of a recording extensometer and, using the formulas developed by Professor Talbot, wheel load was computed.

Figs. 6 and 7. — Measuring strain in the rail by DeForest scratch extensometer. The instrument is shown and part of a record taken under a passing freight train, stretch magnified 200 times. A flat spot on one wheel produced high strain.

The instrument used in measuring strain in the rail was the DeForest scratch extensometer, shown in figure 6. Two clamps, C and C[1], attached to the flange of the rail, carry two flat pieces F and F[1]. One of the flat pieces carries arm A, to the end of which are cemented particles of diamond dust, and the other flat piece carries a plate P, which can be rotated about a horizontal axis and which carries a record strip R of chromium-plated brass. A spring S tends to rotate P and R, but when no stretching is taking place the friction is too great to allow this. However, when stretching is taking place the friction of motion is less than that of rest, and the spring « hitches » the plate a short distance every time that a wheel load passes over the instrument. Figure 7 shows a magnified record taken by this instrument. The actual stretch of flange is recorded unmagnified, and strain is measured by means of a microscope fitted with a micrometer eyepiece. On a single strip records are drawn by a number of different grains of diamond dust, and usually several of these records are sufficiently clear and legible for measuring.

The experimental determination of the range of wheel loads to be expected in service involves the gathering of a large amount of statistical data. Obviously maximum, minimum and average service values of wheel load must be estimated rather than measured.

Data for preliminary estimates have been obtained from observations at two different test locations : on the Baltimore & Ohio Railroad north of Dayton, Ohio, and on the Pennsylvania Railroad near Coatesville, Pa. The maximum wheel loads due to freight-car wheels were found to be as high as any loads observed under locomotive wheels, and the results reported here are for freight-car wheel loads. Records of 53 600 wheel loads as recorded at seventeen test locations for instruments were obtained at Dayton, and of 36 800 wheel loads at eight instrument locations were obtained at Coatesville. Figure 8 shows the relative frequency of loads of different magnitudes.

Both locations represent track in fairly good condition with heavy rail. They represent about average conditions of rolling stock. It is to be noted that at both locations there were occasional wheel loads equal to or greater than 40 000 lb., and it has been noted in rolling-load tests in the laboratory, that spreading internal fissures in shatter-cracked rail specimens were developed by loads as low as 40 000 lb.

At the present time it is not possible to make any quantitative estimate of the relative frequency of high wheel loads caused by track conditions and by rolling-stock conditions. It can be stated with confidence that both are important.

Problem of acceptance tests for rails.

The ideal acceptance test for rails would be a non-destructive test that could be applied to each rail. No such test is available at present. Much study and experimentation have been carried out in attempting to find some reliable non-destructive test for shatter-cracks in rails. Tests of change in electrical resistance, of distortion of magnetic field above a crack, of thermal conductivity, of modification of sound waves by cracks—all these have been tried, but no reliable test has been found. The Sperry test is effective for finding fissures but has not proved sensitive enough to detect shatter-cracks in newly rolled rails.

The only acceptance tests for rails that are available today are tests of specimens to destruction. Such tests are better than no tests at all, but they do not give assurance of rails free from shatter-cracks. The standard strength test for rails is a drop test of specimens, usually three, from a heat of steel. Placed head up on supports 3 to 4 feet apart, a specimen must withstand one

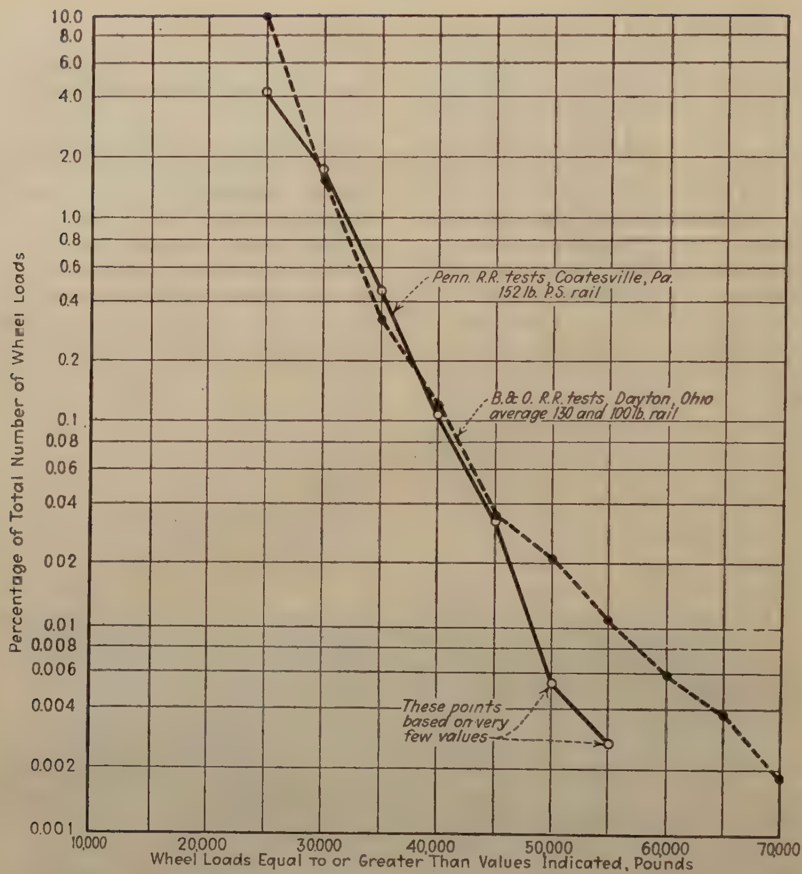


Fig. 8. — Wheel-load frequency in modern freight service. Full line represents records obtained on the Pennsylvania Railroad near Coatesville, Pa., for 36 800 freight-car wheels. Dotted line represents records obtained on the Baltimore & Ohio Railroad near Dayton, Ohio, for 53 659 freight-car wheels.

blow from a 2 000-lb. weight dropped from a height of about 20 feet; the precise height and span depend on the weight of rail under test. Sometimes head-down tests are made. Usually if the specimens withstand one blow, one of them is subjected to repeated blows until it fractures, the number of blows is noted, and the stretch along the lower edge of the rail is measured. This repeated-blow test is not very satisfactory because the first blow so distorts the rail that the stresses set up under successive blows are uncertain and uncontrollable.

The bend test, which has been proposed by a number of engineers and metallurgists, seems to be distinctly better than the drop test. It is a flexural test of a 5- or 6-foot length of rail made in a testing machine or a hydraulic press fitted with autographic recording equipment for drawing a load-deflection diagram. After fracture, the elongation

along the tension edge is measured as in the drop test. The bend test gives all the data of the drop test and load values in addition. The area under the load-deflection diagram measures the energy required for fracture more accurately than does the drop test. Moreover in the bend test the uncertainty of effect of blow due to the distortion of specimen by the first blow is avoided.

The etch test, which consists in etching slices cut from the head of a piece of rail, gives direct evidence of the presence or absence of a shattered condition in the specimen tested by opening up any cracks and making them visible. It also gives some idea whether any cracks present are close to the tread or below the center of the head, where their presence would be less injurious.

Drop, bend and etch tests are all tests of specimens to destruction. Like all tests to destruction these tests leave an element of uncertainty as to whether any specimen tested is representative of worst, average or best conditions of the steel in a heat of rails.

In the course of the present investigation, drop tests, bend tests and etch tests have been carried out on specimens from 74 newly-rolled rails. Table I summarizes the results of drop tests and bend tests as compared with the indications of etch tests. An examination of Table I shows that none of the tests used assure acceptance of all rails free from shatter-cracks, and at the same time rejection of all rails containing shatter-cracks.

TABLE 1.

A STUDY OF RAIL ACCEPTANCE BY VARIOUS TESTS APPLIED TO 74 TEST RAILS.

TEST.	Criterion of acceptance or rejection (1).	Number rejected.		Number accepted.
		Rails free from shatter-crack (2).	Rails with only longitudinal shatter-crack (2).	Rails with transverse shatter-cracks (2).
Bend test				
Energy for fracture .	125 000 ft.-lb.	0	2	2
Elongation	12 % in 1-inch gage length on tension edge.	1	3	2
Drop test, head up, single blow	1 blow, approx. 40 000 ft.-lb. (3).	0	0	5
Elongation	7.5 % for 130-lb. rail; 8.5 % for 110-lb. rail (1).	3	2	2
Drop test, head down. single blow	1 blow, approx. 40 000 ft.-lb. (3).	0	1	3
Elongation	7.5 % for 130-lb. rail; 8.5 % for 110-lb. rail (1).	0	1	3

(1) Arbitrary values, selected by test party.
(2) Shatter-cracks as shown by etch tests of 6-inch specimen from end of broken rail specimen.
(3) A. S. T. M. standard test.

Effect of thermal treatment.

To gain some idea of the effectiveness of proposed processes for preventing shatter-cracks by the thermal treatment of rails after rolling, tests were made on 36 pairs of rails furnished by various

mills. One rail of each pair had been cooled in the usual way on a hotbed, while the other rail, usually from the same ingot as the first and always from the same heat, had been given a special thermal treatment. Two types of thermal treatment were studied :

(1) a controlled cooling of the rail after rolling, and

(2) a normalizing process in which, after rolling, the rail was allowed to cool through its critical range in air, then reheated above the critical range to a temperature producing grain refinement, and then cooled in air. (See *Railway Age* for March 2, 1935, for description of this process).

From Mill L (two pairs of rails) hotbed rails showed shatter-cracks, low results in bend test and developed fissures in rolling-load test, while control-cooled rails showed no shatter-cracks, good results in bend tests and developed no fissures in rolling-load tests.

From Mill E (five pairs) two hotbed rails showed shatter-cracks, one showed a low result in the bend test, two withstood rolling-load test (2 000 000 repetitions of 75 000-lb. wheel load) without fissure; control-cooled rails showed no shatter-cracks, good results in bend test, and under rolling-load test one rail developed failure in web, not a fissure in head.

From Mill D (five pairs) hotbed rails showed many shatter-cracks, gave low results in bend test, and one developed fissure in rolling-load test; normalized rails showed a few shatter-cracks in three rails, gave good bend-test results and developed no fissures in rolling-load tests of three rails.

From Mill B (twelve pairs) no shatter-cracks were found either in hotbed rails or in control-cooled rails. Control-cooled rails showed distinctly higher values in bend tests than hotbed rails. No fissures developed in rolling-load tests.

From Mill I, second lot of Mill E and second lot of Mill D (twelve pairs), no shatter-cracks were found either in hotbed rails or in thermally treated rails, good results were obtained in all bend tests, and no fissures have yet developed in rolling-load tests.

No appreciable lowering of Brinell hardness was observed for any of the thermally treated rails as compared with the corresponding hotbed rails. The tests so far made indicate distinct improvement of quality due to all of the thermal treatments studied.

Low-temperature tests.

Rail failures are more frequent in cold weather than in warm weather. Two causes are found for this : (1) changed track conditions due to freezing and thawing; and (2) changed physical properties of rail steel at low temperatures.

The second of these causes was studied by a series of tests made in the cold room of the U. S. Air Service laboratories at Wright Field, Dayton, Ohio, which were made available for the rails investigation. Tests were made on specimens cut from three newly rolled rails : rail 1017, a hotbed rail in which etch tests had shown shatter-cracks; rail 1018, a control-cooled rail free from shatter-cracks; and rail 1063, a hotbed rail free from shatter-cracks. Fatigue tests, impact tests, tensile tests and Brinell tests were made with minimum temperatures of —40° F. for fatigue tests, and —53° F. for impact tests and tensile tests.

Figure 9 shows the results of the low-temperature tests. It will be noted that the strength values (yield strength, tensile strength, fatigue limit and Brinell hardness) increase as temperature decreases, with the exception of tensile strength of notched specimens. Ductility values (elongation, reduction of area, impact values both for notched speci-

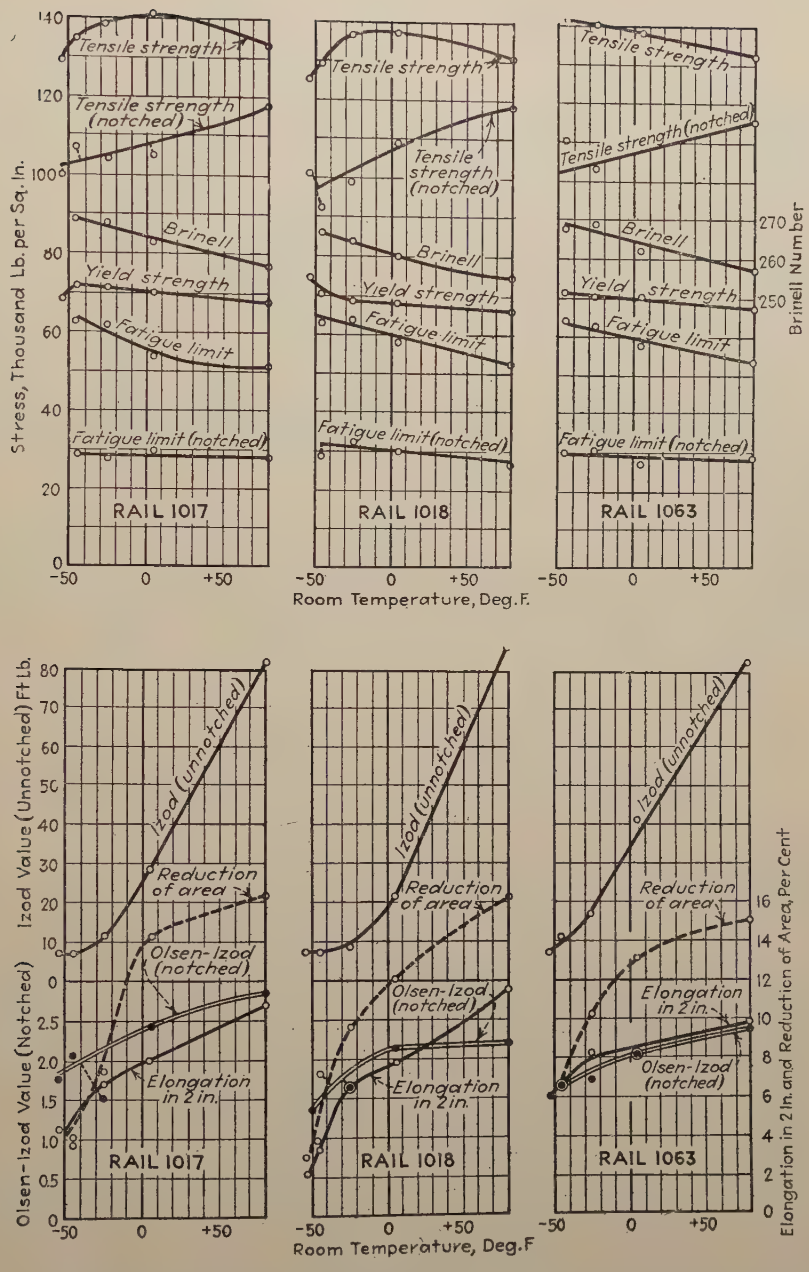


Fig. 9. — Steel at low temperature has lessened ductility, according to tests carried down to 50 degrees F. below zero.

mens and for unnotched decrease, as found in previous tests elsewhere.

Metallographic studies.

In connection with the work of the investigation, many metallographic studies of the structure of rail steel have been carried out and also studies of the effect of nitrogen and oxygen in rail steel. These studies have failed to show any correlation with the presence or absence of a shattered steel condition.

Studies of the internal strains in railheads have shown rather small strains, and in the shatter-crack zone the strains have been found to be compressive rather than tensile, checking results found by other investigators. It should be noted that the strains left *after cooling* give no measure of the strains set up *while the rail is cooling.*

Comparative tests of specimens from near the surface of rails with tests of specimens from the center of the head have been made on a few rails. Specimens from rails in which etch tests had shown shatter-cracks gave distinctly lower values of tensile strength, fatigue strength, impact values, elongation and reduction of area than did specimens from rails in which etch tests had shown no shatter-cracks.

This report is a progress report, and the behavior in service of test rails may throw new light on the problem of internal fissures. The results of the investigation so far emphasize the importance of freedom from shatter-cracks in rail steel; indicate that thermal treatment of rails after rolling may markedly reduce trouble from this source; emphasize the importance of careful track maintenance and of maintenance of rolling stock in reducing the actual wheel loads to which rail is subjected; and emphasize the desirability of developing a more effective acceptance test for rails than the drop test now in common use.

[313 : 625. 143. 3]

Statistics of rail breakages for the years 1933 and 1934.

(Continued).

We publish hereafter, in the form adopted at the Madrid Congress (1930) [1], the information supplied by member Administrations in connection with the rail fractures which occurred on their lines during the combined years 1933 and 1934.

The first part of these statistics appeared in the December 1935 number of the *Bulletin*, pp. 1455 to 1486.

In the tables hereafter, and unless stated otherwise [2] :

Light rails *applies to rails of a weight less than 85 lb. per yard (42.5 kgr. per metre),*

Medium rails, *to rails of 85 to 105 lb. per yard (42.5 to 52.5 kgr. per metre),*

Heavy rails, *to those weighing 106 lb. per yard (53 kgr. per metre) or over.*

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(1) See *Bulletin of the Railway Congress*, December 1930, pp. 2236, 2240-2242.
(2) See *Bulletin of the Railway Congress*, March 1926, p. 240.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
FRANCE. Colonies and Protectorates. **ALGERIA.** **Algerian State Railways.**		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light*	...	...	...	3	372.8	5	...	...	...	8	466.0	10.6	35	1 009.1	21.5	46	1 847.9	15.4	17.3
Medium	...	...	...	4	339.3	7.3	...	...	...	...	...	...	...	...	...	4	339.3	7.3	
Total	...	...	...	7	712.1	6.3	...	...	...	8	466.0	10.6	35	1 009.1	21.5	50	2 187.2	14.2	
B. Rails in tunnels. *Light*	...	...	...	...	...	...	...	4.00	...	...	...	...	...	...	...	...	4.0	...	17.3
Medium	...	...	...	...	3.4	...	...	...	...	...	...	...	...	...	...	...	3.4	...	
Total	...	...	...	...	3.4	...	...	4.00	...	...	...	...	...	...	...	...	7.4	...	
C. The whole of A and B. *Light*	...	...	...	3	372.8	...	...	4.00	...	8	466.0	...	35	1 009 1	...	46	1 851.9	...	
Medium	...	...	...	4	342.7	...	...	...	...	...	...	...	...	...	...	4	346.7	...	
Total	...	...	...	7	715.5	...	...	4 00	...	8	466.0	...	35	1 009.1	...	50	2 198.6	14.1	

Number of { train-miles : 16 840 690.
English ton-miles : 4 972 420 000.

Number of fractures { total : 50.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 18.4.
per 1 billion tkm. or 612 000 000 English ton-miles : 6.1.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails*	30 %	62 %	41	3	2	32	14
Medium rails	...	8 %	4	...	...	3	1
		Total	45	3	2	35	15
		Miles of single track of each class.	1 336.0	862 6		1 421.7	776.9

E		*Light rails.*	*Medium rails.*
a) New clean fractures	with internal transverse fissure	2	...
	without internal transverse fissure	11	3
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	15	1
	in the head	12	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	10	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Paris-Lyons-Mediterranean Railways. **Algerian Lines.**		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light*	...	...	...	...	...	...	...	...	...	1	202.6	3	38	341.8	69	39	514.4	44.5	17.3
Medium	...	...	...	...	240.5	...	...	...	...	...	...	...	...	...	...	...	240.5	...	16.8
Heavy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Total	...	...	...	...	240.5	...	...	...	...	1	202.6	3	38	341.8	69	39	784.9	30.8	
B. Rails in tunnels. *Light*	...	...	...	...	...	...	...	4.9	...	...	...	...	...	...	...	...	4.9	...	17.3
Medium	...	...	...	...	0.9	...	...	...	...	...	...	...	...	...	...	...	0.9	...	16.8
Heavy	...	1.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1.5	...	
Total	...	1.5	...	...	0.9	...	...	4.9	...	...	...	...	...	...	...	...	7.3	...	
C. The whole of A and B. *Light*	...	...	...	...	...	...	...	4.9	...	1	202.6	3	38	341.8	69	39	549.3	...	
Medium	...	...	...	...	241.4	...	...	...	...	...	...	...	...	...	...	...	241.4	...	
Heavy	...	1.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1.5	...	
Total	...	1.5	...	...	241.4	...	...	4.9	...	1	202.6	3	38	341.8	69	39	792.2	30.5	

Number of { train-miles : 10 149 040.
English ton-miles : 2 996 700 000.

Number of fractures { total : 39.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 23.8.
per 1 billion tkm. or 612 000 000 English ton-miles : 7.9.

	Number of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D *Light rails*	2	37	30	6	3	26	13
Medium rails	...	...	...	...	...	...	...
Heavy rails	...	...	...	...	...	...	...
Total			30	6	3	26	13
Miles of single track of each class.			528.1	264.1		456.7	335.5

	Light.	*Medium.*	*Heavy.*
E. *a*) New clean fractures { with internal transverse fissure	1	...	...
without internal transverse fissure	5	...	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head { in the head	10	...	...
in the foot	11	...	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head { in the web	12	...	...
d) Number of pieces rails are broken into	2	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TUNIS. Cie fermière des Chemins de fer Tunisiens.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light*	...	7.5	...	...	45.3	...	...	...	...	4	106.2	...	108	817.5	...	112	976.5	71.2	
Medium	...	...	...	...	0.5	...	1	20.9	...	...	...	...	...	...	...	1	21 4	28.9	
Total	...	7.5	...	...	45.8	...	1	20.9	...	4	106.2	...	108	817.5	...	113	997.9	70.3	
B. Rails in tunnels. *Light*	...	...	...	...	...	...	...	...	...	...	0.4	...	...	1.2	...	...	1.6	...	...
Medium	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Total	...	...	...	...	...	...	...	...	...	...	0.4	...	...	1.2	...	...	1.6	...	
C. The whole of A and B. *Light*	...	7.5	...	...	45.3	...	...	...	...	4	106.6	...	108	818.7	...	112	978.1	71.1	
Medium	...	...	...	...	0.5	...	1	20.9	...	...	...	...	...	..	...	1	21.4	28.9	
Total	...	7.5	...	...	45.8	...	1	20.9	...	4	106.6	...	108	818.7	...	113	999.5	70.2	

Number of { train-miles : 4 422 030. English ton-miles : 9 746 290 300.

Number of fractures { total : 113. per 10 000 000 tr.-km. or 6 250 000 000 train-miles : 159. per 1 billion tkm. or 612 000 000 English ton-miles : 71.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails.*	36 %	64 %	96	12	4	112	1
Medium rails	...	100 %	1	...	...	...	...
		Total	97	12	4	112	1
	Miles of single track of each class.		889.8	109.7		770.3	229.3

E.	*Light rails.*	*Medium rails.*
a) New clean fractures { with internal transverse fissure	13	...
without internal transverse fissure	37	1
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head { in the foot	26	...
in the head	4	...
c) Fractures with much rusted old part, *not* extending { in the web	32	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cie des Phosphates et du Chemin de fer de Gafsa.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels:																			
Light	...	...	...	...	...	...	...	...	...	...	...	...	3	151	12.34	3	151	12.34	9.8

Number of { train-miles : 21 306 760.
English ton-miles : 5 718 387 250.

Number of fractures { total : 3.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 0.87.
per 1 billion tkm. or 612 000 000 English ton-miles : 0.32.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails.* . .	...	100 %	2 (straight lines). 1 (40-chain curve).	...	...	2 (level track). 1 (1 in 125 gradient).	...
	Total . . .		3	...	...	3	...
	Miles of single track of each class.		151	...	...	151	...

E.	*Light rails.*
a) New clean fractures { with internal transverse fissure	...
a) New clean fractures { without internal transverse fissure	2
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head { in the foot	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head { in the head	1
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head { in the web	...
d) Number of pieces rails are broken into	2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
MOROCCO. Cie des Chemins de fer du Maroc.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light*	...	...	...	...	278.1	...	...	...	...	...	...	...	...	...	...	...	278.1	...	19.7
Medium	1	302.4	2.05	...	...	...	...	...	...	...	...	...	...	...	...	1	302.4	2.05	
Heavy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Total	1	302.4	2.05	...	278.1	...	...	...	...	...	...	...	...	...	...	1	580.5	1.06	
B. Rails in tunnels. *Light*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Medium	...	1.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1.4	...	
Heavy	...	6.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6.8	...	
Total	...	8.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.2	...	
C. The whole of A and B. *Light*	...	...	...	...	278.1	...	...	...	...	...	...	...	...	...	...	...	278.1	...	
Medium	1	303.8	2.04	...	...	...	...	...	...	...	...	...	...	...	...	1	303.8	2.04	
Heavy	...	6.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6.8	...	
Total	1	310.6	2.00	...	278.1	...	...	...	...	...	...	...	...	...	...	1	588.7	1.05	

Number of { train-miles : 2 486 090.
English ton-miles hauled : 345 669 854.

Number of fractures { total : 1.
per 10 000 000 tr.-km. or 6 250 000 trains-miles : 2.5.
per 1 billion tkm. or 612 000 000 English ton-miles : 1.8.

	Percentage of fractures in the part covered by the fishplates.	Percentage of fractures in the part clear of the fishplates.	NUMBER OF FRACTURES. On straight lines or curves of > 800 m. (40 chains) radius.	On curves of ⩽ 800 m. (40 chains) radius: Lower rail.	On curves of ⩽ 800 m. (40 chains) radius: Higher rail.	On a rising or falling gradient ⩽ 10 mm. per m. (1 in 100).	On a rising or falling gradient > 10 mm. per m. (1 in 100).
D. *Light rails*	...	...	...	...	...	...	...
Medium rails	100 %	...	1	...	...	1	...
Heavy rails	...	...	...	...	...	...	...
Total			1	...	...	1	...
Miles of single track of each class.			478.7	110.0		367.2	101.5

		Light rails.	*Medium rails.*	*Heavy rails.*
E. a) New clean fractures	with internal transverse fissure	...	...	...
	without internal transverse fissure	...	1	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	...	...	...
	in the head	...	...	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	...	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Other Colonies in Africa.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Chemin de fer Franco-Ethiopien de Djibouti à Addis-Abeba.																			
A. Rails outside tunnels. *Light*	...	...	...	...	...	...	...	...	...	...	...	...	1	192.0	3.236	1	192 0	3.236	8.0

Number of { train-miles : 692 600. / English ton-miles : 54 324 950.

Number of fractures { total : 1. / per 10 000 000 tr.-km. or 6 250 000 train-miles : 8.9. / per 1 billion tkm. or 612 000 000 English ton-miles : 11.3.

	Percentage of fractures in the part: covered by the fishplates.	Percentage of fractures in the part: clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	on curves of ⩽ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D. *Light rails.*	...	100 %	...	1	...	...	1
	Miles of single track of each class.		156.1	35.9		126.9	65.1

E.	*Light rails.*
a) New clean fractures { with internal transverse fissure	1
a) New clean fractures { without internal transverse fissure	...
d) Number of pieces rails are broken into	2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Over 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Colonial Railways in French West Africa.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails.																			
a) **Dakar-Niger System** .	...	...	...	...	...	...	2	414.5	10.72	...	...	...	26	477.8	33.8	28	892.3	19.5	10 and 10.8
b) **Conakry-Niger System**	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
c) **Bénin-Niger System** .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
d) **Abidjan-Niger System.** (Year 1934.)	2	205.7	6.04	1	106.2	5.84	...	...	...	1	190.8	3.25	...	...	...	4	502.7	4.9	13.7

Number of train-miles { a) Dakar-Niger : 2 864 420. d) Abidjan-Niger (1934) : 568 785.

Number of fractures { total : a) Dakar-Niger : 28; b) Abidjan-Niger : 4. per 10 000 000 tr.-km. or 6 250 000 train-miles · { a) Dakar-Niger : 60.8. b) Abidjan-Niger (1934) : 43.6.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
a) **Dakar-Niger System** .							
D. *Light rails.* . .	...	28 = 100 %	...	...	...	...	...

E		*Light rails.*
a) New clean fractures {	with internal transverse fissure	4
	without internal transverse fissure	1
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head . . . . {	in the foot	21
	in the head	2
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head . . . {	in the web	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Chemin de fer et Port de la Réunion.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. } *Light* (*).	...	...	...	1	72.2	8.6	...	...	...	...	...	...	...	...	...	1	72.2	8.6	4.9
B. Rails in tunnels. } *Light* (*).	...	...	...	1	6.2	100.0	...	...	...	...	...	...	...	...	...	1	6.2	100.0	
C. The whole of A and B. } *Light* (*).	...	...	...	2	78.4	15.8	...	...	...	...	...	...	...	...	...	2	78.4	15.8	
Total . . .	...	...	...	2	78.4	15.8	...	...	...	...	...	...	...	...	...	2	78.4	15.8	

Number of train-miles : 531 370. Number of English ton-miles : 9 873 000.

(*) 52.4 lb. per yard.

	Percentage of fractures in the part: covered by the fishplates.	Percentage of fractures in the part: clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	on curves of ≤ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D *Light rails.* . .	...	...	2	...	...	...	...
	Miles of single track of each class.		...	...		...	...

	Light rails.
E. *a)* New clean fractures { with internal transverse fissure	...
a) New clean fractures { without internal transverse fissure	2
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head . . . . . . { in the foot	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head . . . . . . { in the head	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head . . . { in the web	...
d) Number of pieces rails are broken into	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ASIA. **Chemin de fer de Damas-Hama & Extensions.**		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. *Light rails* outside tunnels.																			
Beyrouth-Damas: 92.6 miles (N. G.) Rayak-Alep: 205.7 miles (S. G.) Homs-Tripoli: 63.4 miles (S. G.)	...	...	...	1	92.6	6.7	5	156.0	20.0	3	298.3	6.2	19	298.3	39.5	28	361.6	48.1	12.5 N.G. 13.0 S.G.

Number of { train-miles : 1 509 830. / English ton-miles : 68 970 700.

Number of fractures { total : 28. / per 10 000 000 tr.-km. or 6 250 000 train-miles : 115. / per 1 billion tkm. or 612 000 000 English ton-miles : 248.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails.*	4 %	96 %	3	17	8	2	18
	Miles of single track of each class.		298.3	361.6		93.6	298.3

E.		*Light rails.*
a) New clean fractures	with internal transverse fissure	...
	without internal transverse fissure	16
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	3
	in the head	3
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	6
d) Number of pieces rails are broken into		...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
INDO-CHINA. Chemins de fer coloniaux de l'Indochine.																			
(*a*) **Northern System.**																			
A. Rails outside tunnels. *Light*	2	37.9	32.78	...	...	...	...	...	...	...	...	...	13	369.1	21.90	15	603.3	15.45	...
B. Rails in tunnels. *Light*	...	...	...	...	...	...	...	...	...	...	...	...	1	1.9	333.33	2	1.9	333.33	...
C. The whole of A and B. *Light*	2	37.9	32.78	...	...	...	...	...	...	...	...	...	14	371.0	23.48	15	605.2	16.45	...

Number of { train-miles : 2 774 775. / English ton-miles : 329 705 300.

Number of fractures { total : 16. / per 10 000 000 tr.-km. or 6 250 000 train-miles : 35.85. / per 1 billion tkm. or 612 000 000 English ton-miles : 29.56.

	Percentage of fractures in the part		NUMBER OF FRACTURES:				
	covered by the fishplates.	clear of the fishplates.	on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	on curves of ⩽ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D. *Light rails.*	8.33 %	91.67 %	15	1	...	16	...
	Miles of single track of each class.		509.5	95.7		575.4	29.8

E.		*Light rails.*
a) New clean fractures	with internal transverse fissure	3
	without internal transverse fissure	7
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	3
	in the head	2
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	1
d) Number of pieces rails are broken into	cracked	6
	2 pieces	10

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
b) **Southern System.**		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light*	...	57.1	...	...	12.6	...	...	...	...	...	25.2	...	11	265.6	25.74	11	360.5	18.93	10.4
B. Rails in tunnels. *Light*	...	0.5	...	...	0.1	...	...	...	...	...	...	...	...	...	...	...	0.6	...	10.8
C. The whole of A and B. *Light*	...	57.6	...	...	12.7	...	...	...	...	...	25.2	...	11	265.6	25.74	11	361.1	18.93	...

Number of { train-miles : 1 450 350.
English ton-miles : 156 283 500.

Number of fractures { total : 11.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 47.10.
per 1 billion tkm. or 612 000 000 English ton-miles : 43.0.

	Percentage of fractures in the part: covered by the fishplates.	Percentage of fractures in the part: clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	on curves of ≤ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D. *Light rails.*	...	...	7	1	2	...	1

		Light rails.
E. *a)* New clean fractures	with internal transverse fissure	...
	without internal transverse fissure	2
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	...
	in the head	8
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	1
d) Number of pieces rails are broken into		...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Compagnie française des Chemins de fer de l'Indochine et du Yunnan. (*)		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A Rails outside tunnels. *Light*	...	9.8	...	...	10.6	...	...	...	...	...	...	...	13 br. 70 cr.	498.0	16 br. 87 cr.	13 br. 70 cr.	518 4	16 br. 84 cr.	
B Rails in tunnels. *Light*	...	1.2	...	...	3.9	...	...	...	...	...	...	...	1 br. 10 cr.	7.0	88 br. 882 cr.	1 br. 10 cr.	12.1	50 br. 509 cr.	...
C. The whole of A and B. *Light*	...	11.0	...	...	14.5	...	...	...	...	...	...	...	14 br. 80 cr.	505.0	17 br. 98 cr.	14 br. 80 cr.	530.5	16 br. 94 cr.	

Number of { train-miles : 2 574 600. English ton-miles : 84 925 250.

Number of fractures { total : 14 broken, 80 cracked. per 10 000 000 tr.-km. or 6 250 000 train-miles : 34 broken, 193 cracked. per 1 billion tkm. or 612 000 000 English ton-miles : 100 broken, 576 cracked.

	Percentage of fractures in the part		NUMBER OF FRACTURES :				
	covered by the fishplates.	clear of the fishplates.	on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius		on a rising or falling gradient	
				Lower rail.	Higher rail.	⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D *Light rails.*	7 % broken, 2.5 % cracked.	93 % broken, 97.5 % cracked.	4 broken, 12 cracked.	7 broken, 41 cracked.	3 broken, 27 cracked.	0 broken, 6 cracked.	6 broken, 61 cracked.
	Miles of single track of each class.		360.2	170.3		177.8	110.2

E.		*Light rails.*
a) New clean fractures	with internal transverse fissure	4 broken, 19 cracked.
	without internal transverse fissure	2 broken.
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	3 broken, 21 cracked.
	in the head	4 broken, 30 cracked.
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	1 broken, 10 cracked.
d) Number of pieces rails are broken into		2

(*) Haiphong-Yunnanfou line.
This Company specially mentions the case of a rail taken out of the track owing to segregation due to insufficient cropping of the ingot head.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GREAT BRITAIN. Great Western Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Medium* .	1	...	...	2	...	...	6	...	...	3	...	...	11	...	...	23	...	...	22.5
B. Rails in tunnels. *Medium* .	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	
C. The whole of A and B. *Medium* .	2	...	...	2	...	...	6	...	...	3	...	...	11	...	...	24	5 290	2.83	

Number of { train-miles : 124 818 500. English ton-miles : 5 787 199 939.

Number of fractures { total : 24. per 10 000 000 tr.-km. or 6 250 000 train-miles : 1.20. per 1 billion tkm. or 612 000 000 English ton-miles : 2.54.

	Percentage of fractures in the part: covered by the fishplates.	Percentage of fractures in the part: clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	on curves of ⩽ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D. *Medium rails* . .	29.17 %	70.83 %	22	1	1	4	20
	Total . . .		22	1	1	4	20
	Miles of single track of each class.		Not known.				

E.		*Medium rails.*
a) New clean fractures	with internal transverse fissure	6
	without internal transverse fissure	3
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	5
	in the head	8
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head . .	in the web	2

ADMINISTRATIONS AND DESCRIPTION OF RAILS.							10 to 15 years.			15 to 20 years.			More than 20 years.						Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
London Midland & Scottish Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light*	...	2	...	...	29	...	...	72	...	...	49	...	...	670	...	...	822	...	18.5
Medium	23	2 667	5.4	49	2 511	12.2	35	1 997	10.9	17	1 143	9.3	39	4 017	6.1	163	12 335	8.3	22.5
Total	23	2 669	5.4	49	2 540	12.1	35	2 069	10.6	17	1 192	8.9	39	4 687	5.2	163	13 157	7.7	
B. Rails in tunnels. *Light*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Medium	3	124.5	15.1	7	67	65 2	2	21	59.5	...	19.25	...	...	4	...	12	235.75	31.8	22.5
Total	3	124.5	15.1	7	67	65.2	2	21	59.5	...	19.25	...	...	4	...	12	235.75	31.8	
C. The whole of A and B. *Light*	...	2	...	...	29	...	...	72	...	...	49	...	...	670	...	...	822	...	18.5
Medium	26	2 791.5	5.9	56	2 578	13.6	37	2 018	11.5	17	1 162.25	9.1	39	4 021	6.1	175	12 570.75	8.7	22 5
Total	26	2 793.5	5.9	56	2 607	13.4	37	2 090	11.1	17	1 211.25	8.8	39	4 691	5.2	175	13 392.75	8.2	

Number or { train-miles : 293 795 829. English ton-miles : 9 438 167 720.

Number of fractures { total : 175. per 10 000 000 tr.-km. or 6 250 000 train-miles : 3.73. per 1 billion tkm. or 612 000 000 English ton-miles : 11.3

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails*	...	...	...	...	...	...	...
Medium rails	11.4 %	88.6 %	153	11	11	161	14
		Total	153	11	11	161	14
		Miles of single track of each class.	11 929	1 854		11 959	1 824

E.	*Light rails.*	*Medium rails.*
a) New clean fractures { with internal transverse fissure	...	11
without internal transverse fissure	...	111
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head { in the foot	...	12
in the head	...	27
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head { in the web	...	14
d) Number of pieces rails are broken into	...	150 in 2 pieces. 22 » 3 » 2 » 4 » 1 » 5 »

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
London & North Eastern Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light* . .	...	12.34	...	...	33.63	...	...	24.95	...	...	49.24	...	3	1 273.18	1.47	3	1 393.34	1.35	20
Medium .	20	1 041.94	12.0	15	1 302.95	7.20	11	1 344.18	5.11	3	717.74	2.61	16	3 855.74	2.59	65	8 262.52	4.92	22.5
Total . .	20	1 054.25	11.86	15	1 336.58	7.01	11	1 369.13	5.02	3	766.98	2.44	19	5 128.92	2.32	68	9 655.86	4.40	
B. Rails in tunnels. *Light* . .	...	...	...	...	0.44	...	...	...	...	...	...	...	...	2.04	...	...	2.48	...	20
Medium .	9	62.76	89.63	3	22.51	83.30	1	11.35	55.07	...	2.39	...	4	4.44	563.06	17	103.45	102.71	22.5
Total . . .	9	62.76	89.63	3	22.95	81.70	1	11.35	55.07	...	2.39	...	4	6.48	385.80	17	105.93	100.30	
C. The whole of A and B. *Light* . .	...	12.34	...	...	34.07	...	...	24.95	...	...	49.24	...	3	1 275.22	1.47	3	1 395.82	1.34	20
Medium .	29	1 104.67	16.41	18	1 325.46	8.49	12	1 355.53	5.53	3	720.13	2.60	20	3 860.18	3.24	82	8 365.97	6.13	22.5
Total . . .	29	1 117.01	16.23	18	1 359.53	8.27	12	1 380.48	5.43	3	769.37	2.41	23	5 135.40	2.80	85	9 761.79	5.44	

Number of { train-miles : 182 940 963.
English ton-miles : 8 786 218 875.

Number of fractures { total : 85.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 2.91.
per 1 billion tkm. or 612 000 000 English ton-miles : 5.92.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails.* . .	33 %	67 %	3	...	...	2	1
Medium rails . .	16 %	84 %	71	7	4	12	44
		Total . . .	74	7	4	14	45
	Miles of single track of each class.		8 652.79	1 109.00		2 552.78	6 221.24

		Light rails.	*Medium rails.*
E. a) New clean fractures	with internal transverse fissure	...	3
	without internal transverse fissure	2	51
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	...	4
	in the head	1	12
	in both head and foot	...	6
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web		

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			... of the rails.			Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Southern Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles		English tons.
A. Rails outside tunnels. *Light*	...	...	...	...	0.3	...	...	3.1	...	...	0.9	...	1	79.1	7.9	1	83.4	7.5	
Medium	15	719.9	13.0	5	852.6	3.7	5	846.7	3.7	3	187.9	10.0	4	1 175.9	2.1	32	3 783.0	5.3	
Heavy	...	...	...	...	...	...	...	..	...	...	...	...	...	0.1	...	...	0.1	...	
Total	15	719.9	13.0	5	852.9	3.7	5	849.8	3.7	3	188.8	10.0	5	1 255.1	2.5	33	3 866.5	5.3	
B. Rails in tunnels. *Light*	...	...	...	...	...	...	...	...	...	...	...	...	...	0.3	...	...	0.3	...	21
Medium	3	60.7	30.9	4	16.6	150.6	1	5.9	105.9	...	0.2	...	...	4.0	...	8	87.4	57.2	
Heavy	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Total	3	60.7	30.9	4	16.6	150.6	1	5.9	105.9	...	0.2	...	...	4.3	...	8	87.7	57.0	
C. The whole of A and B. *Light*	...	...	...	...	0.3	...	...	3.1	...	...	0.9	...	1	79.4	7.9	1	83.7	7.5	
Medium	18	780.6	14.4	9	869.2	6.5	6	852.6	4.4	3	188.1	10.0	4	1 179.9	2.2	40	3 870.4	6.5	
Heavy	...	...	...	...	...	...	...	...	...	...	...	...	...	0.1	...	...	0.1	...	
Total	18	780.6	14.4	9	869.5	6.5	6	855.7	4.4	3	189.0	9.9	5	1 259.4	2.5	41	3 954.2	7 9	

Number of train-miles : 128 017 635.

Number of fractures { total : 41. per 10 000 000 tr.-km. or 6 250 000 trains-miles : 2.0.

	Number of fractures in the part.		NUMBER OF FRACTURES:				
	covered by the fishplates.	clear of the fishplates.	on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius — Lower rail.	on curves of ⩽ 800 m. (40 chains) radius — Higher rail.	on a rising or falling gradient — ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient — > 10 mm. per m. (1 in 100).
D. *Light rails*	...	1 = 100 %	1	...	...	1	...
Medium rails	9 = 22.5 %	31 = 77.5 %	36	1	3	38	2
Heavy rails	...	...	...	...	...	...	...
		Total	37	1	3	39	2
		Miles of single track of each class.	...	...		...	...

E.		*Light rails.*	*Medium rails.*	*Heavy rails.*
a) New clean fractures	with internal transverse fissure	...	13	...
	without internal transverse fissure	1	27	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	...	...	...
	in the head	...	...	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	...	...	...
d) Number of pieces rails are broken into	Two	1	28	...
	Three	...	6	...
	Four	...	3	...
	Five	...	2	...
	Seven	...	1	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
London Passenger Transport Board.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Medium* .	1	51.10	12.2	1	26.21	23.8	...	26.29	...	...	38.71	...	...	42.79	...	2	185.10	6.7	20 (Steam locos. on portions of L.P.T.B. lines).
B. Rails in tunnels. *Medium* .	6	61.40	61.1	9	26.61	211.4	...	30.46	...	1	7.58	82.4	4	31.55	72.3	20	160.60	77.8	14.5 and 11.5 Electric stock.
C The whole of A and B. *Medium* .	7	112.50	38.8	10	52.82	118.3	...	56.75	...	1	46.29	13.5	4	77.34	32.3	22	345.70	39.77	...

Number of { train-miles : 55 500 000.
English ton-miles : 8 900 000 000.

Number of fractures { total : 22 (including 8 bridge rails).
per 10 000 000 tr.-km. or 6 250 000 train-miles : 2.47.
per 1 billion tkm. or 612 000 000 English ton-miles : 1.51.

	Number of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius. (including 40 chs.)	on curves of ⩽ 800 m. (40 chains) radius (excluding 40 chs. radius). Lower rail.	Higher rail.	on a rising or falling gradient ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Medium rails* . .	8	14	16	3	3	9 level. 2 rising. 1 falling.	7 rising. 3 falling.
	Miles of single track of each class.		227.70	118.00		255.70	90.00

		Medium rails.
E. *a)* New clean fractures	with internal transverse fissure	...
	without internal transverse fissure	22
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	...
	in the head	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head . . .	in the web	...
d) Number of pieces rails are broken into		2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cheshire Lines Committee.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. } *Medium.*	4	63.825	...	...	55.250	...	1	54.750	...	...	54.250	...	...	53.037	...	5	281.112	...	20.9
B. Rails in tunnels. } *Medium.*	...	2.375	...	...	2.363	...	...	2.362	...	...	...	...	...	...	...	...	7.100	...	...
C. The whole of A and B. } *Medium.*	4	66.200	...	...	57.613	...	1	57.112	...	...	54.250	...	...	53.037	...	5	288.212	...	...

Number of { train-miles : 9 950 000. English ton-miles : 313 000 000.

Number of fractures { total : 5. per 10 000 000 tr.-km. or 6 250 000 train-miles : 3.14. per 1 billion tkm. or 612 000 000 English ton-miles : 9.77.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Medium rails* . .	20 %	80 %	4	1	...	2	Néant.
	Miles of single track of each class.		272	16		...	...

		Medium rails.
E. *a)* New clean fractures	with internal transverse fissure	2
	without internal transverse fissure	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	...
	in the head	3
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	...
d) Number of pieces rails are broken into		...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Great Central and Midland Joint Line.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Medium.*	...	10.36	...	...	3.66	...	...	5.50	...	...	1.5	...	...	5.0	...	..	26.02	...	22
B Rails in tunnels. *Medium.*	...	0.64	...	...	0.09	...	...	...	...	...	...	...	...	...	...	...	0.73	...	22
C. The whole of A and B. *Medium.*	...	11.0	...	...	3.75	...	...	5.50	...	...	1.5	...	...	5.0	...	...	26 75	...	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Midland and Great Northern Railways Joint Line.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A Rails outside tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	..	2	...	20.0
Medium.	...	11	...	...	22	...	...	14	...	...	7	...	...	205	...	...	259	...	
Total . . .	...	11	...	...	22	...	..	14	...	...	7	..	...	207	...	...	261	...	

Number of { train-miles : 3 142 235.
{ English ton-miles : 129 838 318.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Great Northern Railway (Ireland).		Miles			Miles.			Miles.			Miles.			Miles			Miles.		English tons.
A. Rails outside tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	10	115	54	10	115	54	17

Number of train-miles : 6 486 065.

Number of fractures { total : 10. per 10 000 000 tr.-km. or 6 250 000 train-miles : 9.6.

	Percentage of fractures in the part: covered by the fishplates.	Percentage of fractures in the part: clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	on curves of ⩽ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D. *Light rails.*	40 %	60 %	8	...	2	...	10
	Miles of single track of each class.		731			731	

		Light rails.
E. *a*) New clean fractures	with internal transverse fissure	4
	without internal transverse fissure	
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	2
	in the head	1
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	3
d) Number of pieces rails are broken into		2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
INDIA, DOMINIONS, PROTECTORATES & COLONIES. AFRICA. Kenya and Uganda Railways and Harbours.		Miles			Miles.			Miles.			Miles			Miles			Miles		English tons.
A. Rails outside tunnels. *Light.*	...	109	...	13	473	17	4	275	9	...	23	...	18	745	15	35	1 625	15.7	80 lb. : 18 tons. 50 lb : 12 tons

Number of { train-miles : 5 022 915. English ton-miles : 672 034 242.

Number of fractures { total : 35. per 10 000 000 tr.-km. or 6 250 000 train-miles : 43.4. per 1 billion tkm. or 612 000 000 English ton-miles : 31.5.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails.*	...	100 %	26	6	3	20	15
	Miles of single track of each class.		No record kept.				

E.		*Light rails.*
a) New clean fractures	with internal transverse fissure	...
	without internal transverse fissure	35
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	...
	in the head	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	...
d) Number of pieces rails are broken into		2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Nigerian Railway.		Miles.			Miles.			Miles.			Miles			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	...	98.5	...	...	491.75	...	7	426.75	10.25	1	157	3.93	23	726.75	19.8	31	1 900.75	10.21	16.5

Number of { train-miles : 6 774 931.
English ton-miles : 2 253 672 473.

Number of fractures { total : 31.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 28.6.
per 1 billion tkm. or 612 000 000 English ton-miles : 8.56.

	Percentage of fractures in the part: covered by the fishplates.	Percentage of fractures in the part: clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	on curves of ⩽ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D. *Light rails*	12.9 %	87.1 %	13	5	13	Single-line track.	

E. *a)* New clean fractures { with internal transverse fissure . . . .
without internal transverse fissure . . . .

b) Fractures with much rusted old part, extending to the outer surface of the foot or the head . . . . { in the foot . . . .
in the head . . . .

c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head . . . { in the web . . . .

d) Number of pieces rails are broken into . . . .

} No details.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sudan Railways and Steamers (*).		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails 50 lb.	...	11.2	...	1	473.5	1.31	...	...	...	...	13.0	...	14	805.9	10.79	15	1 303.6	7.15	12.4
Light rails 75 lb.	...	0 6	...	...	38.5	...	...	36.0	...	...	16.8	...	5	583.5	5.32	5	775.4	4.60	16 0
Total . . .	...	11.8	...	1	512.0	1.21	...	6.0	...	...	29.8	...	19	1 389.4	8.49	20	2 079.0	6.28	

Number of { train-miles : 3 168 650.
English ton-miles : 1 608 269 200.

Number of fractures { total : 20.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 39.22.
per 1 billion tkm. or 612 000 000 English ton-miles : 7.60.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails* 50 lb.	...	100 %	15	...	...	15	...
Light rails 75 lb.	20 %	80 %	5	...	...	5	...
		Total . . .	20	...	...	20	...
		Miles of single track of each class.	...	...		...	...

E.	*Light rails.* 50 lb.	75 lb.
a) New clean fractures — with internal transverse fissure	...	...
a) New clean fractures — without internal transverse fissure	7	3
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head — in the foot	...	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head — in the head	1	..
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head — in the web	2	...
d) Crushed or plit head	5	2

(*) Main line.

SOUTH AFRICAN RAILWAYS AND HARBOURS.

Fractures of rails: Broken rails removed from the track during years 1st January, 1933 — 31st December, 1934.

Age of rails.	Light section. 35-46 1/4 lb.	Medium section: 60-61 lb.	Heavy section: 75-96 lb.
Less than 5 years	...	4	46
5 to 10 years	1	16	52
10 to 15 years	...	2	59
15 to 20 years	1	14	34
Over 20 years..	110	165	166
Age unknown (rail marks obliterated).	21	200	81
Total . . .	133	401	438
Mileage of single track	2 567.73	6 157.64	4 867.7
Number of fractures per 1 000 km. or 625 miles	32.37	40.70	56.24
Maximum axle load (tons of 2 240 lb.).	10.5	13.5	18.5

Total mileage: Route miles	13 217.21
Total mileage: Track miles (excluding loops and sidings)	14 111.0
Total number of fractures of all classes of rail	972
Number of train-miles (1-1-33 to 31-12-34)	88 583 136
Number of fractures per 10 000 000 tr.-km. or 6 250 000 train-miles	68.57

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
INDIA.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles		English tons.
Bengal and North Western Railway.																			
A. Rails outside tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	20	2 122.74	5.89	20	2 122.74	5.89	10

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rohilkund and Kumaon Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	10	682.75	9	10	682.75	9	9.5

	Percentage of fractures in the part: covered by the fishplates.	Percentage of fractures in the part: clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	on curves of ⩽ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient: > 10 mm. per m. (1 in 100).
D. *Light rails:*							
Bengal and North Western Ry.	...	100 %	...	...	...	...	...
Rohilkund and Kumaon Ry.	...	100 %	10	...	...	..	...

E. *d)* Number of pieces rails are broken into: 2.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Bombay, Baroda and Central India Railway. (5 ft 6 in, gauge).		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light*	...	...	...	...	...	...	...	...	...	...	...	...	6	700.830	5.351	6	700.830	5.351	5.95 14.00 17.75 17.90
Medium	...	...	...	...	...	...	...	...	...	...	...	...	5	1 297.363	2.409	5	1 297.363	2.409	21.45 electric rake.
Total	...	...	...	...	...	...	...	...	...	...	...	...	11	1 998.193	7.670	11	1 998.193	7.670	

Number of { train-miles : 14 973 436. English ton-miles : 7 029 867 340.

Number of fractures { total : 11. per 10 000 000 tr.-km. or 6 250 000 train-miles : 4.59. per 1 billion tkm. or 612 000 000 English ton-miles : 0.95.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D *Light rails*	100 %	40 %	100 % on curves.			...	...
Medium rails	20 %	80 %	100 % on straight lines.			...	...

E		*Light rails.*	*Medium rails.*
a) New clean fractures	with internal transverse fissure	...	...
	without internal transverse fissure	...	5
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	3	...
	in the head	3	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	...	...
d) Number of pieces rails are broken into		2 (generally).	

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Bombay, Baroda and Central India Railway. (Metre gauge).		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	...	...	...	2	2 623.07	0.47	...	...	...	...	...	...	57	2 623.07	13.58	59	2 623.07	14.05	8 tons over 41.25-lb. rails and 10 tons over 50 and 60-lb. rails.

Number of { train-miles : 15 301 810. English ton-miles : 1 256 339 909.

Number of fractures { total : 59. per 10 000 000 tr.-km. or 6 250 000 train-miles . 24.10. per 1 billion tkm. or 612 000 000 English ton-miles · 28.73.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails* . .	10.17	89.83	58	...	...	...	1

E.		*Light rails.*
a) New clean fractures	with internal transverse fissure	...
	without internal transverse fissure	41
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	15
	in the head	1
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	5
d) Number of pieces rails are broken into		2 (47 rails)

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Burma Railways.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	2	190	6.5789	...	...	...	2	87	14.3678	3	1 080	1.7361	14	907	9.6472	21	2 264	5.7972	10

Number of { train-miles : 14 311 063. English ton-miles : 4 825 047 636.

Number of fractures { total : 21. per 10 000 000 tr.-km. or 6 250 000 train-miles : 9.1712. per 1 billion tkm. or 612 000 000 English ton-miles : 2.6636.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails*	23.81 %	76.19 %	21	...	...	5	4
	Miles of single track of each class.		...	...		...	263.38

		Light rails
E. *a)* New clean fractures	with internal transverse fissure	7
	without internal transverse fissure	1
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	9
	in the head	2
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	2
d) Number of pieces rails are broken into		2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS : Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Great Indian Peninsula Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	42	3 347.1	7.85	42	3 347.1	7.85	
Medium.	...	320	...	8	727.7	6.86	3	397.7	4.71	2	109	11.47	5	860	3.63	18	2 414.4	4.66	
Heavy	...	...	...	1	3.3	189.4	...	...	...	...	...	...	...	...	...	1	3.3	189.4	
Total	...	320	...	9	731	7.69	3	397.7	4 71	2	109	11.47	47	4 207.1	6.98	61	5 764.8	6.78	
B. Rails in tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	...	0.9	...	...	0.9	...	
Medium.	...	...	...	...	2.3	...	...	2.3	...	...	...	...	...	...	...	...	4.6	...	17.55
Heavy	...	...	...	...	3.7	...	...	...	...	...	...	...	...	...	...	...	0.7	...	20.9
Total	...	...	...	...	3	...	...	2.3	...	...	...	...	...	0.9	...	...	6.2	...	
C. The whole of A and B. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	42	3 348	7.84	42	3 348	7.84	
Medium.	...	320	...	8	730	6.85	3	400	4.69	2	109	11.47	5	860	3.63	18	2 419	4.65	
Heavy	...	...	...	1	4	156.25	...	...	...	...	...	...	...	...	..	1	4	156.25	
Total	...	320	...	9	734	7.66	3	400	4.69	2	109	11.47	47	4 208	6.97	61	5 771	6.66	

Number of { train-miles : 36 858 229. English ton-miles : 21 212 903 888.

Number of fractures { total : 61. per 10 000 000 tr.-km. or 6 250 000 train-miles : 10.304. per 1 billion tkm. or 612 000 000 English ton-miles : 1.759.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius	on a rising or falling gradient ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails*	7 %	93 %	29	13	42	...
Medium rails	33 %	66 %	6	12	13	5
Heavy rails	...	100 %	...	1	...	1
		Total	35	26	55	6

		Light rails.	*Medium rails.*	*Heavy rails.*
E. a) New clean fractures	with internal transverse fissure	Not known.	6	1
	without internal transverse fissure	Information not available.		
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	Information not available.		
	in the head	Information not available.		
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	Information not available.		

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Madras & Southern Mahratta Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A Rails outside tunnels. *Light* .	...	155.51	...	1	357.56	1.75	...	256.17	...	...	174.87	...	46	1 832.96	15.68	47	2 777.07	10.58	
Medium .	...	49.25	...	1	321.31	1.95	...	135.75	...	...	...	...	...	4.50	...	1	510.81	1.22	
Total . . .	...	204.76	...	2	678.81	1.84	...	391.92	...	...	174.87	...	46	1 837.46	15.65	48	3 287.88	9.12	
B. Rails in tunnels. *Light* . .	...	0.87	...	...	0.82	...	...	0.33	...	...	0.13	...	...	0.11	...	...	2.26	...	17.5
Medium .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Total . . .	...	0.87	...	...	0.82	...	...	0.33	...	...	0.13	...	...	0.11	...	...	2.26	...	
C. The whole of A and B. *Light* . .	...	156.38	...	1	358.38	1.74	...	256.50	...	...	175 00	...	46	1 833.07	15.68	47	2 779.33	10.57	
Medium .	...	49.25	...	1	321.31	1.95	...	135.75	...	...	...	...	...	4.50	...	1	510.81	1.22	
Total . . .	...	205.63	...	2	679.69	1.84	...	392.25	...	...	175.00	...	46	1 837.57	15.65	48	3 290.14	9.12	

Number of { train-miles : 26 854 000.
English ton-miles : 10 663 761 000.

Number of fractures { total : 48.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 11.17.
per 1 billion tkm. or 612 000 000 English ton-miles : 2.7.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails* . .	17.02	82.98	38	4	5	24	...
Medium rails .	...	100	...	1	...	...	...
		Total . . .	38	5	5	24	...
		Miles of single track of each class.	3 083.50	206.64		1 843.13	64.72

E		*Light rails.*	*Medium rails.*
a) New clean fractures	with internal transverse fissure	13	...
	without internal transverse fissure	15	1
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	13	...
	in the head	1	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	5	...
d) Number of pieces rails are broken into		2	2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
South Indian Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	2	236.46	5.29	...	519.75	...	...	113.11	...	2	132.69	9.42	6	1 278.70	2.93	10	2 280.71	2.74	(*)
Medium.	...	72.30	...	...	97.06	...	...	82.24	...	...	...	...	...	...	...	...	251.60	...	
Total . . .	2	308.76	5.29	...	616.81	...	...	195.35	...	2	132.69	9.42	6	1 278.70	2.93	10	2 533.64	2.74	
B. Rails in tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1.33	...	...	1.33	...	
Medium.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Total . . .	...	...	...	...	...	...	...	...	...	...	...	...	...	1.33	...	...	1.33	...	
C. The whole of A and B. *Light.*	2	236.46	5.29	...	519.75	...	...	113.11	...	2	132.69	9.42	6	1 280.03	2.93	10	2 282.04	2.74	
Medium.	...	72.30	...	...	97.06	...	...	82.24	...	...	...	...	...	...	...	...	251.60	...	
Total . .	2	308.76	5.29	...	616.81	...	...	195.35	...	2	132.69	9.42	6	1 280.03	2.93	10	2 533.64	2.74	

(*) *Broad gauge:* 90 and 80-lb. rails = 17.875 tons. — 75-lb. rails = 16.62 tons. — 60-lb. rails = 15.55 tons.
Metre gauge: 75-lb. rails = 17.51 tons. — 50 and 60-lb. rails = 10 tons. — 41 1/4-lb. rails = 8.15 tons. — 40-lb. rails = 7.91 tons.
Narrow gauge: 30-lb. rails = 6.24 tons.

Number of { train-miles : 24 725 288.
English ton-miles : 6 280 763 720.

Number of fractures { total : 10.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 2.53.
per 1 billion tkm. or 612 000 000 English ton-miles : 0.97.

	Percentage of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails* .	10 %	90 %	9	1	...	9	1
Medium rails .	...	...	...	...	...	...	...
		Total . . .	9	1	...	9	1
		Miles of single track of each class.	2 374.64	159.00		2 226.38	307.26

E.		*Light rails.*	*Medium rails.*
a) New clean fractures	with internal transverse fissure . . .	3	...
	without internal transverse fissure . . .	7	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head . . .	in the foot . . .	1	...
	in the head . . .	7	...
c) Fractures with much rusted old part, *not* extending	in the web . . .	2	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ceylon Government Railway.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	...	...	...	...	...	...	7	..	4.5	...	..	...	5	...	3.3	12	...	...	...
A. Rails outside tunnels. *Medium.*	...	...	...	2	...	1.3	...	...	...	...	...	...	2	...	1.3	4	...	...	...
Total . . .	...	...	...	2	...	1.3	7	...	4.5	...	...	...	7	...	...	16	..	...	...
B. Rails in tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...
B. Rails in tunnels. *Medium.*	...	...	...	1	...	0.66	1	...	0.66	...	...	...	...	...	...	2	...	.	...
Total . . .	...	...	...	1	...	0.66	1	...	0.66	...	...	...	...	...	...	2	...	...	...
C. The whole of A and B. *Light.*	...	...	...	...	...	...	7	...	4.5	...	...	...	5	...	3.3	12	...	...	...
C. The whole of A and B. *Medium.*	...	...	...	3	...	1.97	1	...	0.66	...	...	...	2	...	1.3	6	...	...	.
Total . . .	...	...	...	3	...	...	8	...	...	...	...	...	7	...	...	18	...	...	...

Number of train-miles: 4 137 397.

	Number of fractures in the part: covered by the fishplates.	clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	Higher rail.	on a rising or falling gradient: ⩽ 10 mm. per m. (1 in 100).	> 10 mm. per m. (1 in 100).
D. *Light rails*	8	4	11	2	12	...	1
D. *Medium rails*	4	2	1	4	...	...	2
		Total . . .	12	6	12	...	3

E.	*Light rails.*	*Medium rails.*
a) New clean fractures with internal transverse fissure	...	2
a) New clean fractures without internal transverse fissure	...	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head: in the foot	6	1
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head: in the head	2	1
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head: in the web	...	2
d) Number of pieces rails are broken into	...	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	AGE OF RAILS: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	The whole of the rails. Number of fractures.	The whole of the rails. Length of single track of this class.	The whole of the rails. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
IRAK. Iraq Railways.																			
A. Rails outside tunnels. *Light.*	...	...	...	...	...	...	...	...	...	...	...	...	4	202	12.4	4	202	12.4	9.7

Number of train-miles : 2 407 294.
Number of English ton-miles : 245 052 909.

Number of fractures: total : 4.
per 10 000 000 tr.-km. or 6 250 000 train-miles : 10.39.
per 1 billion tkm. or 612 000 000 English ton-miles 9.99.

	Percentage of fractures in the part covered by the fishplates.	Percentage of fractures in the part clear of the fishplates.	NUMBER OF FRACTURES: on straight lines or curves of > 800 m. (40 chains) radius.	on curves of ⩽ 800 m. (40 chains) radius: Lower rail.	on curves of ⩽ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient ⩽ 10 mm. per m. (1 in 100).	on a rising or falling gradient > 10 mm. per m. (1 in 100).
D *Light rails* . . .	...	100 %	on straigt lines : 4.	...	...	on level : 4.	
	Miles of single track of each class.		202	...	...	...	...

E	*Light rails.*
a) New clean fractures: with internal transverse fissure	4
a) New clean fractures: without internal transverse fissure	...
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head: in the foot	..
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head: in the head	...
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head: in the web	...
d) Number of pieces rails are broken into	2

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			The whole of the rails.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NEW ZEALAND. New Zealand Government Railways.		Miles.			Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
A. Rails outside tunnels. *Light.*	2	329	3.8	3	446	4.2	4	131	19.1	4	582	4.3	140	1 826	47.9	153	3 314	28.9	16.0
B. Rails in tunnels. *Light.*	...	8	...	1	6	104	...	2	...	...	2	...	1	6	104	2	23	54.1	
C. The whole of A and B. *Light.*	2	337	3.7	4	452	5.5	4	133	18.8	4	584	4.3	141	1 832	48.1	155	3 337	29.1	

Number of { train-miles : 20 771 667. English ton-miles : 4 169 055 843.

Number of fractures { total : 155. per 10 000 000 tr.-km. or 6 250 000 train-miles : 46.7. per 1 billion tkm. or 612 000 000 English ton-miles : 22.8.

	Percentage of fractures in the part		NUMBER OF FRACTURES :				
	covered by the fishplates	clear of the fishplates	on straight lines or curves of > 800 m. (40 chains) radius	on curves of ≤ 800 m. (40 chains) radius: Lower rail.	on curves of ≤ 800 m. (40 chains) radius: Higher rail.	on a rising or falling gradient: ≤ 10 mm. per m. (1 in 100)	on a rising or falling gradient: > 10 mm. per m. (1 in 100)
D *Light rails* .	66 %	34 %	100	39	16	107	48
		Total . . .	100	39	16	107	48
		Miles of single track of each class.	2 514	823		2 503	834

		Light rails.
E. *a)* New clean fractures	with internal transverse fissure	...
	without internal transverse fissure	11
b) Fractures with much rusted old part, extending to the outer surface of the foot or the head	in the foot	62
	in the head	44
c) Fractures with much rusted old part, *not* extending to the outer surface of the foot or the head	in the web	38
d) Number of pieces rails are broken into		2 to 4

NEW BOOKS AND PUBLICATIONS.

[385 (06 (.460)]

Tres años de politica ferroviaria (*Three years of railway policy*). 1st May 1932 to 30th April 1935. Publication No. 33 issued by the Associacion General de Transportes por Via ferrea. — One volume (9 1/2 × 6 3/4 inches), of 516 pages. — 1935, Published by the Association, 26, Calle del Prado, Madrid.

The General Association of Railway Carriers has undertaken the defence of the railway companies, including tramways. It considers it is absolutely necessary that the prosperity of such undertakings should be maintained or restored, not only to preserve the large capital invested in them, but also in the interests of the general economy of the country.

The mode of action followed is to study the principal problems affecting the railways and tramways and to bring them to the notice of the public and all the interested circles by means of pamphlets limited in object and kept within reasonable bounds. It also includes direct intervention with the public authorities and especially the Government and Parliament, by presenting reports on schemes under discussion. The resulting documentation, when added to that of the joint designing office of the *Norte* and *M. Z. A.* Railways includes practically all available information on matters of general interest affecting the Spanish railways.

The Association has done much to dissipate the anti-railway feeling and to make the transport problem better understood. In many instances it has secured favourable decisions.

The objects of the Association's publication No. 6 on the proposed law on the legal and fiscal position of mechanical road transport and the co-ordination of transport, and No. 28 on the Committees dealing with claims for relief of charges have been dealt with previously.

This volume reports the Association's activities over a period of 3 years which began with the appointment of a responsible Director and has been marked by very much greater activity in dealing with official circles and public opinion. The volume is issued by the present director, Mr. D. Blas Vives.

So as not to duplicate earlier publications and in order that the book may be of practical value, the author has limited himself to reproducing the more interesting documents and to giving a synthetic analysis of cases in which the Association has intervened and the results obtained.

The list of the Association's activities is impressive, which explains that it has had considerable influence on the trend of the Spanish railway policy.

E. M.

[62. (01]

Dott. Ing. A. STECCANELLA. — **Essais de résilience. Unification internationale de l'éprouvette et d'autres recherches** (*Resilience tests. International standardisation of the test piece and other investigations*). — French translation of original Italian article published in *La Metallurgia Italiana*, No. 2, February 1935, XIII. — A pamphlet (12 1/4 × 9 1/4 inches) of 32 pages, with illustrations and many tables. — 1935, Milan, Arti grafiche Stefano Pinelli, Via A. Bordoni, 2.

The author, after describing his work on the standardisation of the resilience test pieces, gives particulars of further experiments made with the 10 × 10 × 55 mm. (25/64 × 25/64 × 2 3/16 in.) test pieces with notches 2, 3 and 5 mm.

(5/64, 1/8 and 13/64 in.) deep. The conclusion he has come to is that the 2 mm. (5/64 in.) notch proposed by the Italian engineers should be the international standard.

He has also investigated the influence of a notch with sharp angles at the bottom, and considers it should be excluded from general use as a supplementary method.

He endeavoured to find the bases on which the results of tests with different notches can be compared.

R. D.

[**385. 1** (.44) & **656** (.44)]

PESCHAUD (Marcel). — **La restauration des chemins de fer et la coordination des transports** (*Rehabilitation of the railways and co-ordination of transport*). Abstracted from the *Revue Politique et Parlementaire*, May, July, September and October 1934. — One volume (9 1/2 × 7 inches) of 128 pages. — 1934, Paris, *Revue Politique et Parlementaire*, 10, rue Auber.

The French railways, like those in many other countries, are passing through a difficult period. The last year's working to show a profit was 1929, and the deficit has increased annually since 1930. The position is ascribed to the world economic crisis and to the increased competition from other forms of transport. However, certain special circumstances which the main-line companies have not failed to stress, the influences of which are analysed in this article, have added to the effects of these two general causes.

It was not within the power of the railways to modify to any serious extent the operating results within the limitations of the laws and regulations in force. The public authorities had to act in the matter.

The first reform introduced resulted from the law of the 8th July, 1933, and the amendment to the 1921 convention attached to it.

The articles of this law and the decrees issued subsequently are many and relate to very diverse points. Our readers are aware of many of them through the articles published monthly on the competition of other methods of transport; they will read with interest in Mr. Peschaud's articles the information about the genesis of the changes in the French railway régime. They will see how far they meet the needs and proposals of the railways and be able to form an opinion on the efficacy expected in interested circles.

Amongst the more recent measures introduced are those relating to the co-ordination of transport and the regulations governing carriage by road and by water. They were drawn up by a Co-ordination Committee set up by the railways and were inspired to a large extent by the advice of the National Economic Council. The decrees putting them into force are legally based on the financial law of February 1934 which authorised the Government to effect all economies required to balance the budget. A number of agreements between the railways and road carriers have been entered into, and others are in preparation.

The author wishes co-ordination to be pursued actively so as to obtain the greatest possible benefit. Should it fail, he feels the only hope lies in its being achieved administratively.

Furthermore he again shows the need for stricter control over heavy vehicles both public and private.

E. M.

[625. 15]

Neville H. COUR PALAIS, Engineer, Bengal-Nagpur Railway. — **Railway points and crossings. — Theory and practice.** — One volume (7 1/2 × 5 inches) of 420 pages, with 15 tables and numerous illustrations. — Calcutta, Thacker, Spink, and Co. (1933) Ltd.; 1935, London, W. Thacker and Co.

This work gives the complete calculations of points and crossings and their many applications.

The design of the connections between the non-parallel lines at the beginning of fans of sidings and of reversing triangles should be specially mentioned.

The author has completed his demonstrations by numerical examples and tables.

This very detailed book has been written to meet the needs of draughtsmen, manufacturers, and the permanent way staff, and although primarily intended for the staff of the Indian Railways and those in British Colonies, it could be of great value to the employees of all railways.

R. D.

[385 (02]

The Railway Handbook, 1935-1936. Published under the guidance of the Editor of *The Railway Gazette*. — One vol. (8 1/2 × 5 1/2 inches) of 96 pages with many tables. — 1935, London, The Railway Publishing Co. Ltd., 33, Tothill Street, Westminster, S.W.1. (Price : 2 sh. 6 d.)

A large amount of detailed information on the English and foreign railways is given in the annual known as the *Universal Directory of Railway Officials and Railway Year Book,* formerly issued as two separate publications : *The Universal Directory of Railway Officials* and *The Railway Year Book.* This work is probably the most complete of its kind, owing to the considerable amount of statistical data it contains. It is also rather a large volume.

The Editor of *The Railway Handbook* has provided a smaller and more modest volume at a much lower price. He has succeeded in this by limiting the information given to brief particulars of the English and Irish railways with most of the statistical and other information formerly published in *The Railway Year Book.* This annual appeared in 1934 for the first time.

The growth of the English and Irish railways is dealt with historically in the first pages. The four English main-line companies were set up by the 1921 Act. The companies they absorbed were themselves the result of amalgamations of many independent companies. An important group was added in 1933, namely the London Passenger Transport Board which absorbed all the London Metropolitan lines with the tramways and omnibus services in the London area.

The statistical data follow, and are of many kinds, such as for example the length of the railways of the world (every ten years from 1840), the growth of electrification (in all countries of the world), the greatest height reached by railways, the longest tunnels, remarkable runs as regards speed and mileage, the systems of brakes in use, and the track gauges.

The statistics of the English railways are more detailed and include particulars of the staff, wages, general financial results, detailed working results, and an analysis of the traffic.

In a chapter with a preface by Sir Ralph Wedgwood C. B., C. M. G., entitled « Facts about British Railways, 1935 », the kind, extent, and quality of the services rendered with the equipment involved and the progress achieved

in methods, rolling stock and equipment, are described and stressed by figures and brief indications.

A note signed by Mr. Roger T. Smith gives a short discussion on the economics of electric traction.

E. M.

[385 (093]

Histoire de la locomotion terrestre. — I. Les chemins de fer (*History of locomotion by land. — I. The railways*). Text and documentation by Charles DOLLFUS and Edgar de GEOFFROY. Published by *L'Illustration*. — One large vol. (16 × 12 inches) of XIV + 376 pages, profusely illustrated, with a number of inset colour plates. — 1935, Paris, *L'Illustration*, 13, rue Saint-Georges. (Price : 195 French francs.)

This well known weekly illustrated journal has already published two works devoted to particular methods of transport : the *History of Aeronautics* and the *History of Navigation*. Consequently it was only fitting to complete the series by a *History of Locomotion by land*. The railways came long after the other methods of communication and transport by land, but the editor made such expedition that the publication of this beautiful volume about them was made to coincide with the celebration of the centenary of the Belgian railways, which was one of the features of the Brussels Exhibition.

The *History of Railways* is a work of exceptional importance. It is an immense mine of information collected from the most diverse and reliable sources, many of which had not hitherto been explored. Private collections, personal archives going back to the origin of the railway supplied many of the documents. The great public scientific centres of London, Paris and Washington contribued to it. Invaluable assistance was given by the railways of many countries, by railway engineers, and learned societies. The technical and scientific reviews were also made use of.

The text is divided into three parts. The first, *The Inception of the Railway*, is written by Mr. Charles DOLLFUS, Curator of the Air Museum. The second, *The Golden Age of the Railway*, relating to the period from 1860 to 1914, and the third, *The Railway today*, are by Mr. Edgar GEOFFROY, Engineer of Naval Works, and Honorary Inspector of the French Nord Railway.

In our opinion, the first part is the most interesting. True, we are shown later on the extraordinary development of the railway, and the author has depicted with rare insight the way they transformed the life of the people and how they contributed to the progress of science, industry and commerce; the last twenty years, the period of modernisation, offers striking achievments. However, from a distance of a hundred years, it is the beginnings which are the most interesting.

The book is splendidly illustrated. The diversity is such that it would be impossible even to give a summary of the pictures and it is difficult to quote some examples. There are portraits of all noteworthy railway men right from the beginning, drawings and engravings showing the first locomotives and their precursors, pictures commemorating important events, reproductions of authentic documents, humorous drawings, photographs of rolling stock, buildings, and railway installations, etc. Constructional work in great variety bearing witness to the engineering skill and daring designs due to railway initiative have inspired the pencil or brush of many well known artists.

This luxuriously produced book is a worthy homage by the authors and their collaborators to the railway pioneers and to all those who have helped to perfect this admirable and powerful method of transport.

E. M.

[385. (09.2]

OBITUARY.

General ATTERBURY,

Member of the Board of Directors, former President of the Pennsylvania Railroad,
Member of the Permanent Commission of the International Railway Congress Association.

We heard with deep regret of the death, on September 20th, after a long illness, of General Atterbury, Member of the Board of Directors and former President of the Pennsylvania Railroad Company.

Born at New Albany, Indiana, on January 31st, 1866, Mr. Atterbury graduated in 1886 from Yale University with the degree of Bachelor of Philosophy. On October 11th, he entered the service of the Pennsylvania Railroad as an apprentice in the Altoona Shops.

He was successively promoted to Assistant Road Foreman of Engines in 1889, Assistant Engineer of Motive Power in 1892, and Master Mechanic in 1893.

In 1896, he was appointed Superintendent of Motive Power of the Pennsylvania Lines East of Pittsburgh and Erie and in 1901, he was promoted to General Superintendent of Motive Power. He was appointed General Manager of the Pennsylvania Lines East of Pittsburgh and Erie in 1903 and, in 1904, was appointed Fifth Vice-President, in charge of Transportation.

In 1911, upon a change in the organisation, he was elected Fourth Vice-President and Director of the Company.

In 1912, when the practice of designating the Vice-Presidents numerically was discontinued, Mr. Atterbury's title was changed to Vice-President in charge of Transportation; on November 15th, 1924, he was elected Vice-President and on October 1st, 1925, he was advanced to the Presidency. In the spring of 1935, owing to illness, he declined to stand for reelection.

During the World War, the Government of the U. S. A. selected Mr. Atterbury to serve his country in France as Director General of Transportation with the rank of Brigadier General.

Mr. Atterbury was a former President of the American Railway Association.

He was one of the most far-seeing business executives of his country, recognized not only in his own field of transportation, but in the industrial and economic world generally. He had the admiration and affection of every one

who was privileged to know him and was the friend of all Pennsylvania Railroad employees.

Mr. Atterbury was a member of the Academy of National Sciences et Philadelphia; American Academy of Political and Social Science; American Legion; American Museum of National History (New York); American Society of the French Legion of Honour; American Philosophical Society; American Society of Mechanical Engineers; Franklin Institute of Pennsylvania; Historical Society of Pennsylvania; Indiana Society, Sons of the American Revolution; Military Order of the World War; National Aeronautic Association; Pennsylvania Academy of Fine Arts, Society of Military Engineers, etc., etc.

He held the degree of Master of Arts or Doctor of Laws or Engineering in various Universities.

Until his death, he continued as a member of the Board of Directors of the Pennsylvania Railroad Company and subsidiary companies.

He was also a Director or member of the Board of Management of several other important undertakings of a varied nature.

In his passing, the railway industry of the U. S. A. lost one of its most constructive and outstanding leaders.

Mr. Atterbury was always much interested in the work of the International Railway Congress Association; he had been a member of its Permanent Commission since 1920. His death is keenly felt by his former colleagues and on their behalf we wish to convey our sincerest sympathy to his family and to the Pennsylvania Railroad Company.

The Executive Committee.

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